The Institution of Gas Engineers

JOURNAL

OCTOBER 1961
VOLUME 1 NUMBER 10

BALFOUR OF LEVEN

offer to the Gas Industry a complete service covering design and installation for the most modern types of plant

GAS TREATMENT PLANT

Tower Box Purifiers

Sectional Tower Purifiers

Gas Council Trace Purification Process

Frodingham Process Purifiers

Condensers, Washers, etc.

Conventional Box Purifiers

Giammarco Process

Detoxification

OTHER GAS PLANT

Spiral Guided Gas Holders

Column Guided Gas Holders

Gas Council High Pressure Processes

General Ancillary Plant

Gas Reforming Plant

Smokeless Fuel Plant

Water Gas Plant

Over 150 years in the
BALFOUR GROUP
in Scotland's Industry

Henry Balfour & Company Limited

Other Companies in the Balfour Group:

ENAMELLED METAL PRODUCTS CORPORATION (1933) LTD.

GEORGE SCOTT & SON (LONDON) LTD.

HENRY BALFOUR & CO. LTD.,
LEVEN · FIFE · SCOTLAND.

London Office: Artillery House, Artillery Row, London, S.W.1.
Telephone: ABBey 3639.

PRESSURE-GASIFICATION WITH OXYGEN OF SOLID FUELS IN GERMANY

By Dr.-Ing. HELLMUTH WEITTENHILLER
Chairman of the Board of Directors, Steinkohlengas A.G., Dorsten (Western Germany)

COMMUNICATION No. 589

TABLE OF CONTENTS

		PAGE
I	Summary	655
II	Introduction	656
III	Present Plant Operation	656
	(A) Gas Production and Gas Purification	656
	(B) Recovery of By-Products	657
IV	Improvements in Plant Operation to Date (Increase in gasifier output by lowering the gasification-agent temperature and by steam cooling of rotating grates.)	658
V	New Developments in Processing Techniques	658
	(A) Carbon Monoxide Conversion of Hot Crude Gas, using its Steam Content for the Reaction	658
	(B) Pressure Gasification of Solid Fuels with Oxygen-enriched Air	661
VI	Future Operation and Economic Advantages of Newly Developed Processes	661
	Presentation, Discussion and Reply	663

I SUMMARY

This paper describes the practical operation of the coal-gasification plant, using oxygen under pressure, installed by Steinkohlengas Aktiengesellschaft at Dorsten (Westphalia) nearly six years ago.

By reducing the temperature of the gasification steam and by the application of steam cooling for the rotating grate, the difficulties experienced during initial operation were overcome, and a considerable increase in the gasifier output was achieved. (See Section IV.)

Corrosion problems, mainly caused by chlorine, were solved by providing the inner shells of the gasifiers with a lining of suitable material. This prolonged the working life of the gasifiers to more than 300 days before any maintenance shut-down was required.

There have been a number of new developments recently whereby the conventional Lurgi pressure-gasification process can be considerably improved, and the cost of the gas reduced.

In the crude-gas-conversion plant, which immediately follows the gasification plant (see Section V(A)), the hot crude gas, containing tar and oil vapours, is detoxified, using its steam content for the reaction. Apart from detoxification, the plant removes impurities, such as sulphur compounds and hydrocyanic acid; heavy hydrocarbons contained in the gas are subjected to hydrogenation.

This further permits the direct addition of large quantities of natural gas and nitrogen to the converted high-pressure gas, whereby the production of standard town gas can be increased by more than 50 per cent. Instead of natural gas, refinery gas, mixtures of propane and butane or low-boiling hydrocarbons may also be used for enrichment.

By the introduction of suitable process techniques, using oxygen-enriched air (see Section V(B)) as gasification agent in conjunction with crude-gas conversion, it has been possible to increase steam decomposition to as high as 85 per cent, compared with a maximum of 38 per cent attained hitherto. Not ony does this considerably cut down the production of gas liquor and, therefore, the cost of gas-

liquor treatment, but it also increases the output of purified gas per volume of oxygen and per unit weight of coal (d.a.f.). This higher output is related to the total oxygen consumed, i.e., the oxygen from the air fractionation plant plus the atmospheric oxygen.

The previous requirements of high-pressure steam for gasification are reduced by roughly 35 per cent, and part of the cost of oxygen production can be saved.

The measures described above will also cut down the capital cost of the air fractionation plant to be installed in the future.

The new processing methods are suitable both for town gas and synthesis gas production.

A commercial raw-gas conversion plant for the treatment of 2·3 to 3·0 mill. ft³/h of crude gas is at present under construction, in co-operation with Lurgi, Frankfurt-on-Maine. The plant is expected to be put on stream in November, 1961.

II INTRODUCTION

In view of the rapidly increasing demand for gas in Germany during the past years, new measures had to be taken, particularly to cope with peak-load requirements.

In this connexion Ruhrgas A.G., Essen, initiated the underground storage of large quantities of gas and, on 2nd October, 1953, it established a new company, Steinkohlengas A.G., at Dorsten (Westphalia), to work in the field of complete gasification of coal.

The pressure-gasification plant of the Steinkohlengas A.G., located in the area of the Fürst Leopold-Baldur Colliery at Dorsten, was put into service in September, 1955. The time required for the site erection of the plant was 13 months.

This plant is the first large-scale plant designed for the gasification of caking bituminous coal.

Since starting-up the plant, a lot of difficulties have been overcome and extensive experience and "know-how" collected.

When one tries to frame a very general definition of the term "Pressure gasification", one finds that its basic meaning has been extended in many ways.

Pressure gasification now also covers gasification in slagging gasifiers and gasification of pulverized coal, even though these are still in the trial stage.

It covers also the gasification of liquid feedstocks.

This extension of the fields of application has also nullified the former limitations regarding the high reactivity of the fuel.

In Britain, two large-scale plants are now being installed, one for the Scottish Gas Board and one for the West Midlands Gas Board. The first mentioned has now been put on stream. The installation of further plants is being contemplated.

The main object of this paper is to report on the experience gained from nearly six years of practical plant operation, rather than to deal with the theory of the process or separate process steps.

It would appear, from a comparison between calculated figures and test measurements, that the forecasting of gasification results is possible only to a limited extent. A precise forecast in the real sense of the word cannot be made, as it cannot be predicted to what extent equilibrium will be established.

The following principles of all pressure-gasification processes, excluding the manufacture of synthesis gas, have been considered valid for the past 30 years:

(*a*) elimination of nitrogen dilution by using oxygen of high purity instead of air as gasification agent,

(*b*) formation of a large quantity of methane in the gasifier.

These principles have now been superseded in Germany by our recently developed processes and by the increasing availability of natural gas. Up to a few years ago, natural gas was added to the manufactured gas in order to bring the calorific value up to town gas standard; but in future, considerable quantities of natural gas and nitrogen will be added to the converted gas from the Dorsten pressure-gasification plant, without changing thereby the calorific value and specific gravity of the town gas produced.

The basis for the above processes was established, in co-operation with Lurgi Gesellschaft für Wärmetechnik m.b.H., by the investigation of crude-gas conversion on a laboratory scale, in a pilot plant, and in a semi-technical unit, the latter having a throughput of 900,000 ft³/d of gas.

It may be added that our recent research and development work has brought us one further step forward, and we hope the latest results will be presented in a future report.

III PRESENT PLANT OPERATION

Since so much has been written concerning gasification by the conventional Lurgi pressure-gasification process, I should like to concentrate in this paper on the practical operation of our plant and on the new processes and improvements developed in our works.

(A) Gas Production and Gas Purification

The heart of the plant comprises six gasifiers that were originally designed to supply 46 mill. ft³/d at 450 Btu/ft³. This quantity as well as all town gas data given later include the natural gas necessary to increase the calorific value from 400 Btu/ft³ to 485 Btu/ft³. This constitutes a proportion of about 15 per cent by volume of the town gas. The town gas supplied at an actual calorific value of 485 Btu/ft³ is, in the following, recalculated to a calorific value of 450 Btu/ft³.

The plant is now capable of supplying 75 mill. ft³/d of gas, each pressure gasifier providing 15 mill ft³/d of town gas. There are then five pressure gasifiers working and one serving as standby. During the summer period, only two gasifiers are normally in operation, since our plant is essentially a gas works to cover peak-load requirements, supplying the gas the coke oven plants cannot produce because their gas production is dependent on the coke market. The demand for gas increases much more than that for coke during the winter season. The following example illustrates the great flexibility of our plant:—

Two gasifiers were in operation at a reduced throughput supplying a total of 15 mill. ft³/d of gas, when there was a sudden cold spell. Within a matter of half an hour, the two gasifiers were brought up to full load, i.e., a total output of 30 mill. ft³/d. At the same time, two more gasifiers were put on stream, and were operating at full load after 8 h. Accordingly, after 8 h we were able to supply 60 mill. ft³/ of gas, or four times the initial quantity, to the gas grid. Of course, it would have been possible

to start the fifth gasifier, as well, which would have increased the gas supply to five times the original quantity.

The Dorsten plant processes unwashed weakly-caking high-volatile coal sized 8 to 30 mm. Table 1 shows the average composition of the coal.

TABLE 1.—*Annual Average Coal Analysis.**

1	2
Analysis of run-of-mine coal (per cent) :	
Ash	18·2
Moisture	5·1
Fixed carbon	76·7
Calorific Value (gross) (Btu/lb)	11·160
Ultimate analysis (per cent) :	
Moisture (air-dried)	2·6
C	64·4
H	4·7
O	6·7
S	2·0
N	1·0
Cl	0·4
Ash	18·2
Carbonization assay by Fischer method (per cent/w) :	
Coke	77·2
Tar	11·9
Liquor	6·8
Gas	4·1
Swelling index	1·0 to 1·5
Caking index	8
Size range (mm)	8 to 30
Ash-fusion properties by Bunte-Bcum method (°C) :	
Softening point	910
Medium melting point	1060
Fusion point	1400

* All analysis data according to relevant German D.I.N. Standards.

The initial corrosion troubles due to the high chlorine content, which caused considerable damage to the inner walls of the gasifier, were overcome by lining these walls with suitable material.

Nowadays, we are also in a position to gasify more-strongly-caking coals. It should also, perhaps, be mentioned that we gasified, for experimental purposes, a total of 6,000 tons of American anthracite with an ash content of 35 to 40 per cent and a size range of 4 to 14 mm, with no difficulty.

The Dorsten gasifiers are designed for the processing of bituminous coals with a maximum ash content of 25 per cent. As a result of the experience gained from the above tests, a gasifier for the handling of anthracite would be designed somewhat differently.

The oxygen for our plant is produced in two Linde air fractionation units, each having a capacity of 242,000 ft³/h of oxygen. The installation of an oxygen reserve capacity has so far proved to be unnecessary, as we have sufficient time during the summer to carry out a thorough overhaul, which takes about three weeks per unit.

Two types of tar are collected separately in view of their strong tendency to emulsify; a high-boiling heavy tar recovered from the wash cooler, waste-heat boiler, potassium carbonate heater and gas precooler, and a low-boiling lighter tar from the after-cooler and final cooler. This arrangement permits easy separation of both grades of tar from liquor.

Our oil-wash plant for the removal of the benzole is of conventional design, so that no further comments are needed.

The gas leaving the oil washer is freed from hydrocyanic acid in a small water-wash unit, to avoid contamination in the subsequent Alkazid plant, which reduces the hydrogen sulphide content of the gas from roughly 330 to 30 gr/100 ft³. Removal of residual hydrogen sulphide is carried out in a dry-purification plant using iron oxide. The purified gas enters a hot potassium carbonate plant where carbon dioxide is reduced from roughly 25 per cent to 3 per cent by vol.

The potassium carbonate solution is supplied to the washers at about 175°F and regenerated about 205°F. The necessary heat is normally available practically cost-free, since the solution is used for cooling the gas after the waste-heat boilers, i.e., before the gas coolers.

Certain initial difficulties were overcome by additives to the potassium carbonate solution, and the plant is now operating satisfactorily. The purification cost is only about half the cost of normal-pressure water washing.

Finally, the purified gas is dried by low-temperature cooling and, after adjustment of the calorific value to 485 Btu/ft³ by the addition of natural gas, it is supplied into the Ruhrgas A.G. gas grid at about 270 lb/in² gauge.

The consumption of natural gas in practice depends on the amount of coal gasified.

Large deposits of natural gas were found near the Dutch-German border, especially in the Bentheim region, for which uses had to be found.

In order to increase further the consumption of natural gas at Dorsten, a gas-reforming plant was installed, which uses natural gas at a maximum rate of 8·5 mill. ft³/d.

Roughly 3 mill. ft³/d of this natural gas is reformed at 340 lb/in² gauge with oxygen in the absence of steam. The balance is mixed with nitrogen and added to the treated reformed gas, so that this plant supplies town gas at a rate of up to 14 mill. ft³/d.

(B) RECOVERY OF BY-PRODUCTS

The recovered tar and oil are processed in the works' own tar-distillation plant having a capacity of 75 tons/d.

Although it is general practice in Germany to deliver the tar to central distillation plants, we have not followed this procedure, in order to gain our own experience from the processing of the tar, which would obviously not be possible if our product were treated jointly with others.

The crude benzole recovered from gas washing and from tar and oil distillation is at present subjected to hydrogenation at 355 lb/in² gauge in a separate plant. The purified gas from the works is used for this hydrogenation; the product recovered, containing roughly 70 per cent of aromatics and 30 per cent aliphatics, has a research octane number of 96.

The hydrogen sulphide recovered from the Alkazid lye by steam stripping is burnt to sulphur dioxide with air and then used to make 60° sulphuric acid, with vanadium oxide as catalyst. The sulphuric acid is of such purity that it can readily be used for the production of battery acid. Our sulphuric acid plant has an output of roughly 80 tons of 60° acid per day.

Since the rate of supply of hydrogen sulphide depends on the gas output, additional sulphur is burnt, occasionally. This is recovered from our spent oxide in a central extraction unit.

The phenols are removed from the carbolic oil fraction by extraction with liquor. The enriched liquor, together with the gas condensate, is then dephenolized in a Phenosolvan plant.

We are at present changing from butyl-acetate to *iso*-propylether for phenol extraction. Although the recycle rate of solvent will be greater due to the lower distribution factor, there will be considerable savings in operating costs because (i) the boiling-point of *iso*-propylether (140°F) is lower than for butyl acetate (255°F), (ii) the

latent heat is also lower, and (iii) *iso*-propylether is cheaper than butyl acetate.

The ammoniacal liquor leaving the Phenosolvan plant is of high purity and can be processed into high-grade ammonium sulphate.

The gaseous carbon dioxide leaving the hot potassium carbonate plant at almost 100 per cent purity is freed from the last traces of organic sulphur compounds and hydrogen sulphide, *etc.*, in an active-carbon plant. We have thus an odourless carbon dioxide available for liquefaction and for the production of dry ice. Our present output is roughly 20,000 tons/a of liquid carbon dioxide and dry ice. The liquid carbon dioxide is supplied partly under high pressure at 980 lb/in² gauge, and partly at a lower pressure of about 170 lb/in² gauge to the foodstuffs industry. A quantity of roughly 750,000 ft³/d is supplied to a chemical works.

When the installation of the crude-gas conversion plant described in Section V(A) has been completed, a total of 150,000 tons/a of carbon dioxide will be available, under full load conditions, for the production of liquid and solid carbon dioxide.

By way of comparison, it may be mentioned that the demand in the Federal Republic of Germany is roughly 60,000 tons/a of liquid carbon dioxide and dry ice, and that the total demand in Britain is at present roughly 130,000 tons/a.

IV IMPROVEMENTS IN PLANT OPERATION TO DATE

The following provides a brief survey of the improvements made in order to increase the gasmaking capacity of the plant from the original 46 to 75 mill ft³/d of gas.

When the plant was put into operation, it was a generally accepted principle of pressure gasification that the ratio of high-pressure steam to oxygen should be 35·5 lb of steam to 100 ft³ of oxygen. However, at this ratio only about 25 per cent of the total steam input was decomposed. The remaining 75 per cent was converted from high-cost high-pressure steam (about 380 lb/in² gauge) into low-cost low-pressure steam (70 lb/in² gauge). This obviously increased the price of the gas produced.

There were also some other difficulties. It was found that the water-cooled grates leaked and that water passed into the gasifiers. This resulted in up to 1,000 gal/h of water getting into the gasifier so that it was surprising that the gasifier still kept running.

In the circumstances, it was decided to cool the grate with steam and to use gasifier-jacket steam for this purpose. After the necessary modifications had been made to the gasifier, the gas output increased immediately.

One reason for this was that uncontrolled quantities of water could no longer pass into the gasifier. However, another reason—and this is the more important one—was that the wet jacket steam is now dried and superheated inside the grate by indirect heat exchange with the hot ash.

The next step was to lower the temperature of the high-pressure steam, which reduced the inlet temperature of the steam/oxygen mixture by about 90°F.

The gasifier requires a surplus of steam in the gasification agent to avoid an undue rise of the reaction temperature, resulting in the melting of the ash and the failure of the gasifier.

By the stepwise reduction of the gasification-steam temperature, it was found possible to reduce the amount of surplus steam, which acts as cooling agent, without exceeding the ash-fusion temperature of the coal in the gasifier.

As compared with the previous "wet processing method", steam consumption went down from 9 lb to 5 lb/100 ft³ of purified gas. These modifications also made it possible to increase the coal throughput by 55 per cent.

It was even found possible to increase the output of gas by 70 per cent. The gas contained less carbon dioxide and more carbon monoxide. In comparison, the consumption of oxygen increased only by 45 per cent.

The reduction in the rate of high-pressure steam supply and the increase of total steam decomposition from 25 to 38 per cent by vol. resulted also in a lower production of gas liquor.

A rather pleasant side-effect was that the output of tar, oil and benzole also increased from a total of 16 gal to 18 gal/ton of coal.

This processing method, which we call "dry operation", led to a considerable reduction in the cost of gas.

V NEW DEVELOPMENTS IN PROCESSING TECHNIQUES*

This Section describes two new processes developed at Dorsten, which have led to a considerable improvement in the economics of the Lurgi pressure-gasification process for the production of town gas and synthesis gas.

(A) Carbon Monoxide Conversion of Hot Crude Gas, using its Steam Content for the Reaction

The development of this new process was stimulated by the following considerations:—

(*a*) As already mentioned in Section III(A), the gas industry in the Federal Republic of Germany is making more and more use of the rapidly increasing supplies of natural gas.

The market for natural gas can no longer keep up with the resources found as a result of the exploitation and drilling activities all over the country. In other words, supply exceeds demand. The large resources of natural gas must, therefore, be incorporated into the German town gas supply system at a minimum of cost, but with an optimum of flexibility.

The idea therefore suggested itself to increase the proportion of natural gas that can be added to the gas produced in the Dorsten pressure-gasification plant by the provision of a highly economic conversion process.

Conversion of carbon monoxide with steam according to the equation

$$CO + H_2O \rightleftharpoons CO_2 + H_2$$

in effect converts 1 vol. of carbon monoxide into 1 vol. of hydrogen. Carbon dioxide is afterwards removed to a residual content of roughly 3 per cent by vol.

The prime advantage of this crude gas conversion is the almost complete detoxification of the gas.

* The information and test results given in Section V(A) and V(B) originate from the unpublished Ph.D. thesis of Dipl.-Chem. Harry Schöfl.

The reduction of the specific gravity of the gas during conversion permits the addition of larger quantities of natural gas and nitrogen, without affecting the quality of the town gas.

(*b*) As already explained in Section IV, the conventional Lurgi pressure-gasification process still involved, in spite of the improvements made by the introduction of the "dry processing method", the major disadvantage that less than 40 per cent of the total gasification steam was decomposed.

Tests were directed initially towards the reduction of the carbon monoxide content, in the gasifier itself. It was, however, found that by increasing the rate of gasification steam to 8·2 lb/100 ft³ of crude gas produced, the carbon monoxide content in the purified gas did not drop below 23 per cent. In this so-called "cold operation", the velocity of reactions in the gasifier is decreased considerably, due to an excessive surplus of steam. Moreover, the high consumption of steam is rather costly, and steam decomposition is as low as 22 per cent.

The economic optimum of the gasification-steam rate is normally about 4·7 lb of steam per 100 ft³ of crude gas for the Dorsten plant; the gasification temperature under this condition is just below the ash-fusion temperature of the coal.

These considerations stimulated the idea of converting the hot tar-laden crude gas in a separate unit with the aid of a catalyst.

After initial difficulties had been overcome, our conversion tests on steam-saturated, crude gas proved successful, so that we now have available an excellent and cheap carbon monoxide conversion process.

In our system there are no steam costs, which were the main factor in the conventional carbon monoxide conversion processes. We are now in a position to produce high quality gas, with a carbon monoxide content reduced from 23 to 4 per cent, without the addition of steam.

After the addition of the appropriate quantity of natural gas and nitrogen, which will be discussed later, the carbon monoxide content drops to as low as about 2 per cent, which means that the gas is effectively detoxified.

To illustrate this, I should like to give some further explanations on paragraph (*a*) of the present Section.

The following example illustrates the principles stated above:—

Our plant produces at present 62,300 ft³ of purified gas per ton of coal substance with a calorific value of roughly 400 Btu/ft³, at a specific gravity of 0·464, with 4 per cent of inerts. For the adjustment of the calorific value to 485 Btu/ft³, the addition of 12,100 ft³ of natural gas (930 Btu/ft³) is required, so that the total output of gas with a gross calorific value of 485 Btu/ft³, a specific gravity of 0·436 and 5 per cent of inerts is 74,400 ft³/ton of coal substance during normal operation.

Converting the crude gas down to a residual carbon monoxide content of 6 per cent by vol. (which is the carbon monoxide content of most of the gas produced in the German coke oven plants and gas works), one has the same output of purified gas, i.e., 62,300 ft³. The thermal output remains the same, since 1 vol. of carbon monoxide is converted to 1 vol. of hydrogen, and these two gases have almost the same calorific value. The specific gravity, however, is reduced to 0·273.

Adding 20,000 ft³ of natural gas and 18,600 ft³ of nitrogen (supplied cost-free from the oxygen-generating plant), the specific gravity of the gas is brought back to 0·48, as during normal operation, with a calorific value of 485 Btu/ft³. However, the content of inerts is higher at about 20 per cent, which is still within permissible limits.

This scheme will increase the availability of low-cost peak-load gas by more than 50 per cent. Hence, it is possible to increase the supply of town gas per ton of coal substance by more than 50 per cent within a very short time by the addition of cheap natural gas. Under German economic conditions, this gas is less costly than any other conventional peak-load gas; it is, indeed, not more costly than coke oven gas. The above method also reduces the toxicity of the gas considerably, contrary to the effect of most other peak-load gases from coke gasifiers, oil-cracking or natural gas-reforming plants.

If a higher proportion of carbon dioxide is left in the gas instead of nitrogen, the permissible quantity of natural or refinery gas to be added is much lower, due to the higher specific gravity of the carbon dioxide. Also, carbon dioxide is chemically active in the presence of water, which is a further reason for the preferential addition of nitrogen, particularly if the gas has to be stored.

TABLE 2.—*Increase of Gas Output by Crude-gas Conversion.*

Total	Ft³/ton Coal Substance	Gross C.V. (Btu/ft³)	Specific gravity (Air = 1)	Inerts (Vol. per cent)
1	2	3	4	5
Normal Operation				
Raw gas	82,960	300	0·728	28
Purified gas	62,300	400	0·464	4
Natural gas	12,100	930	0·601	7
"Town gas"	74,400	485	0·486	5
Including Crude-gas Conversion to 6 per cent of carbon monoxide				
Raw gas	96,000	255	0·714	38
Purified gas	62,300	400	0·273	4
Natural gas	12,100	930	0·601	7
"Town gas"	74,400	485	0·326	5
Natural gas	10,040	930	0·601	7
Nitrogen	9,670	—	0·972	100
"Town gas A"	94,110	480	0·420	14·6
Natural gas	20,090	930	0·601	7
Nitrogen	18,600	—	0·972	100
"Town gas B"	113,090	485	0·48	20·7

One Gasifier: Mill. ft³/d.

Minimum capacity: 75 tons × 74,400 ft³/ton .. .. .. 5·6

Maximum capacity: 200 tons × 113,090 ft³/ton .. .. .. 22·6

Ration of maximum capacity to minimum capacity 4

TABLE 3.—*Composition of Gas Without Crude-gas Conversion.*

	Crude Gas	Purified Gas	Purified Natural Gas	Town Gas After Enrichment
1	2	3	4	5
CO Vol. (per cent)	23·0	30·6	—	25·6
CO_2 " " "	27·0	3·0	3·0	3·0
H_2 " " "	39·0	51·8	—	43·4
N_2 " " "	1·0	1·3	4·1	1·8
CH_4 " " "	10·0	13·3	92·9	26·2
Calorific Value (gross) (Btu/ft³)	300	400	930	485
Specific Gravity (Air = 1)	0·727	0·464	0·601	0·486
Wobbe Index	350	585	1,200	690
Organic S (gr/100 ft³)	11·8	6·0	—	4·8
HCN " "	5·0	trace	—	trace
H_2S " "	344	—	—	—

TABLE 4.—*Composition of Gas with Crude-gas Conversion to 6 per cent by vol. Residual Carbon Monoxide.*

1	Crude Gas Before CO Conversion 2	Crude Gas After CO Conversion 3	Purified Gas After CO Conversion 4	Town Gas After Enrichment 5	"Town Gas A" 6	"Town Gas B" 7
CO Vol. (per cent)	23·0	6·0	9·2	7·7	6·1	5·1
CO_2 " " "	27·0	37·1	3·0	3·0	2·7	2·5
H_2 " " "	39·0	47·5	73·2	61·4	48·5	40·4
N_2 " " "	1·0	0·8	1·3	1·8	11·9	18·3
CH_4 " " "	10·0	8·6	13·3	26·1	30·8	33·7
Calorific Value (gross) (Btu/ft³)	300	255	400	485	485	485
Specific gravity (air = 1)	0·727	0·714	0·272	0·325	0·420	0·480
Wobbe index	350	300	765	840	740	690
Organic S (gr/100 ft³)	11·8	1·3	1·3	1·0	0·8	0·7
HCN " "	5·0	0·1*	trace	trace	trace	trace
H_2S " "	344	360	—	—	—	—

* Without HCN wash.

These statements are illustrated by Tables 2, 3 and 4. As will be seen from Table 2, at any specified calorific value the gas can be adjusted to any desired specific gravity within wide limits. The higher the allowable specific gravity of the town gas, the higher the addition of nitrogen and methane mixture can be.

Instead of natural gas, liquefied petroleum gas may be added to the gas, in which case the quantity of additional low-cost peak gas will be reduced only slightly.

The higher output gives our works an increased flexibility in town gas supply. The minimum thoughput of our gasifiers is 75 tons/d of coal substance, equal to a gas output of 5·6 mill. ft³/d. This throughput can be increased to 200 tons/d within a very short time. Accordingly, using crude-gas conversion, a total output of 22·6 mill ft³/d, or roughly four times the minimum output without crude gas conversion, can be achieved.

Only in large-capacity plants can the full benefit from these processes be obtained. Applied to the gas industry, this would mean the integration of small gas works and the establishment of central stations, as has already been done in Great Britain.

If there were a project for the installation of a new central gas works or for the reconstruction of an existing works in a big town, the minimum capacity of the gasifiers should be adapted to the minimum gas demand.

The available operating data of our gasifiers may be taken for a simple example, in which two gasifiers would be designed for a minimum gas output of 5·6 mill. ft³/d/unit. One gasifier would be standby.

Gasifiers have at present an operating period of 300 d before they have to be shut down for a general overhaul which takes about four weeks. During the period from September till June, two gasifiers are available which can supply a peak output of 45 mill. ft³/d, i.e., eight times the minimum output. During the rest of the year, one gasifier with an output of up to 22·6 mill. ft³/d, or four times the minimum output, will be available.

The oxygen plant need not be designed for the same reserve capacity. The requirement of oxygen, using crude-gas conversion, is only 55 per cent of the demand during operation without crude-gas conversion, since the supply of 113,000 ft³ of town gas requires only 62,300 ft³ of crude gas. The requirements of oxygen may be reduced still further by the application of the process described in Section V(B).

A maintenance period of four weeks per year per air separation unit will be quite sufficient, this being also the reason why the Dorsten plant has no standby air separation unit. There is plenty of time during the summer to carry out a thorough overhaul of the oxygen plant.

The situation is also favourable with regard to the gas-cooling and purification equipment. Ammonia washers are not needed, since the ammonia is removed completely by the gas liquor in the condensers at the operating pressure of 285 lb/in² gauge. As in the case of the oxygen plant, the capacity of the oil-wash and Alkazid plant, the dry purification and the potassium carbonate wash-plant need be only 55 per cent of the maximum peak output of town gas.

Purification of the natural gas should preferably be done separately, because only hydrogen sulphide has to be removed. At Dorsten, this step is accomplished in an Alkazid plant, with subsequent dry purification. The hydrogen sulphide removed from the gas is used for the production of sulphuric acid. The purification costs are almost covered by the proceeds from the sale of the sulphuric acid. The installation cost is low, since the equipment need only be designed for a natural gas throughput that is roughly 30 per cent by vol. of the maximum peak gas load.

When using nitrogen for ballasting, as described in the present paper, only a compression unit is required, since cold and pure nitrogen is available from the air separation plant. This unit would have to be designed to handle only 17 per cent of the maximum peak load.

Another point that should be considered when designing large-capacity gas-production and purification equipment from the point of view of maximum peak loads is the possible provision of underground storage or large gasholders. In this case, the pressure-gasification plant might possibly be designed for a smaller capacity since, during a five-day week, peak loads will be required on five days only. Over the week-ends, there may be sufficient time available to refill the gasholders. For the storing of by-products, larger storage tanks could be provided.

The same applies to the gas liquor, which has to be freed from phenols and ammonia. By the provision of adequate storage facilities, the size of these plants could be reduced, if the plants were kept running over the week-ends.

The process for crude-gas conversion, which is one of the factors in achieving this exceptional flexibility, was developed at Dorsten over the last two years in laboratory and pilot-plant experiments.

One of the problems was to find suitable active and sulphur-resistant catalysts for the conversion of the crude gas, which, after removal of dust and droplets, still contains valuable by-products, such as tar, benzole, *etc.*, in the form of vapour, as well as all impurities, such as organic sulphur compounds, hydrogen cyanide, hydrogen sulphide, *etc.*

We have examined in particular the refining effect that certain conversion catalysts have on the hydrocarbon vapours and impurities contained in the crude gas. The results obtained will lead to considerable further improvements in regard to economics and process techniques.

The catalysts used reduced impurities, such as hydrogen cyanide from 5 gr/100 ft³ to 0·1 gr/100 ft³, and organic sulphur compounds from 11·8 gr/100 ft³ to 1·3 gr/100 ft³.

The hydrocarbons boiling up to roughly 750°F remain in the crude gas leaving the gasifier because of their low partial pressure and are subjected to hydrogenation during crude-gas conversion.

The proportion of lower-boiling components, such as benzole, increases at the expense of the higher-boiling components; oils, *etc.*, are desulphurized. Table 5 shows how the quality of the benzole is improved by crude-gas conversion. The analysis of the refined benzole from our hydrogenation plant is given for comparative purposes.

TABLE 5.—*Improvement of Quality of Benzole by Crude-gas Conversion and Hydrogenation.*

	Crude-gas Conversion		Benzole Hydrogenation Plant
	Before	After	
1	2	3	4
Specific gravity at 20°C ..	0·850	0·836	0·832
Bromine number (g/100 ml)	58·0	5·0	10·6
Total sulphur (per cent/w)	0·80	0·11	0·22
Aromatic (per cent/vol.) ..	69·1	68·5	70·0
Olefins (per cent/vol.) ..	16·0	1·6	5·0
Paraffins and napthenes (per cent/vol.)	14·9	29·9	25·0

For reasons of completeness, a further advantage should be mentioned, namely, the reduction of gas liquor, which was largely due to undecomposed steam. The steam decomposition increases from 38 per cent to 50 to 60 per cent, under optimum operating conditions of the gasifiers with crude-gas conversion.

(B) PRESSURE GASIFICATION OF SOLID FUELS WITH OXYGEN-ENRICHED AIR

As mentioned in the previous Sections, a considerable amount of nitrogen has to be added to the town gas in order to adjust its specific gravity.

By the addition of large quantities of air to the gasification agent, and the application of specific process techniques, we have been able to prove, experimentally, that a number of further considerable improvements can be achieved in conventional pressure gasification.

For the purpose of the test, the gas to the pilot conversion plant was taken from the outlet of one generator, which was supplied with oxygen enriched air.

The following gives a brief survey of the advantages gained:—

(1) Steam decomposition, which had been increased to a maximum of 38 per cent by "dry operation" (see Section IV), was further increased to 50 to 60 per cent, using crude-gas conversion, without air addition, and to above 85 per cent by crude-gas conversion with the addition of air, and by the application of specific operating conditions and process techniques.

This new process step enabled the adjustment of a ratio of high-pressure steam: total oxygen of 15·4 lb: 100 ft³ as compared to 23·6 lb: 100 ft³ attained previously, under optimum operating conditions of the gasifiers.

The requirements of high-pressure steam for gasification are reduced by more than 30 per cent, which means a considerable saving in steam cost. Moreover, the output of gas liquor is much lower, due to the lower steam consumption and the high degree of steam decomposition.

In addition, the proportion of carbon monoxide in the crude gas is increased by the present process, and it is then converted into hydrogen and carbon dioxide by using the undecomposed gasification steam contained in the crude gas.

(2) The new process increases the quantity of purified gas (on a nitrogen- and carbon dioxide-free basis) produced in the gasifier per volume of oxygen and unit weight of coal substance consumed.

(3) Since a substantial proportion of the oxygen required for gasification is introduced into the process with the air, less oxygen needs to be produced by air fractionation, resulting in a reduction of power cost.

(4) Also, this has led to a reserve capacity being available in the oxygen plant at Dorsten. With the present two air separation units, using crude gas conversion, it will in the future be possible to produce a maximum output of town gas of 112 mill. ft³/d calculated on a calorific value of 450 Btu/ft³.

If one oxygen unit fails, the gas output would normally drop to 56 mill. ft³/d. Operating with air addition, we cannot use the total amount of air previously added, because the specific gravity of the town gas would become too high. However, we would be able to use some extra air, to produce at least an extra 18 mill. ft³ of gas, which means that the output would drop only to 74 mill. ft³/d and not to 56 mill. ft³/d, in case of one unit failing.

In other words, the oxygen plant can in future be designed for a smaller capacity, resulting in the saving of investment cost.

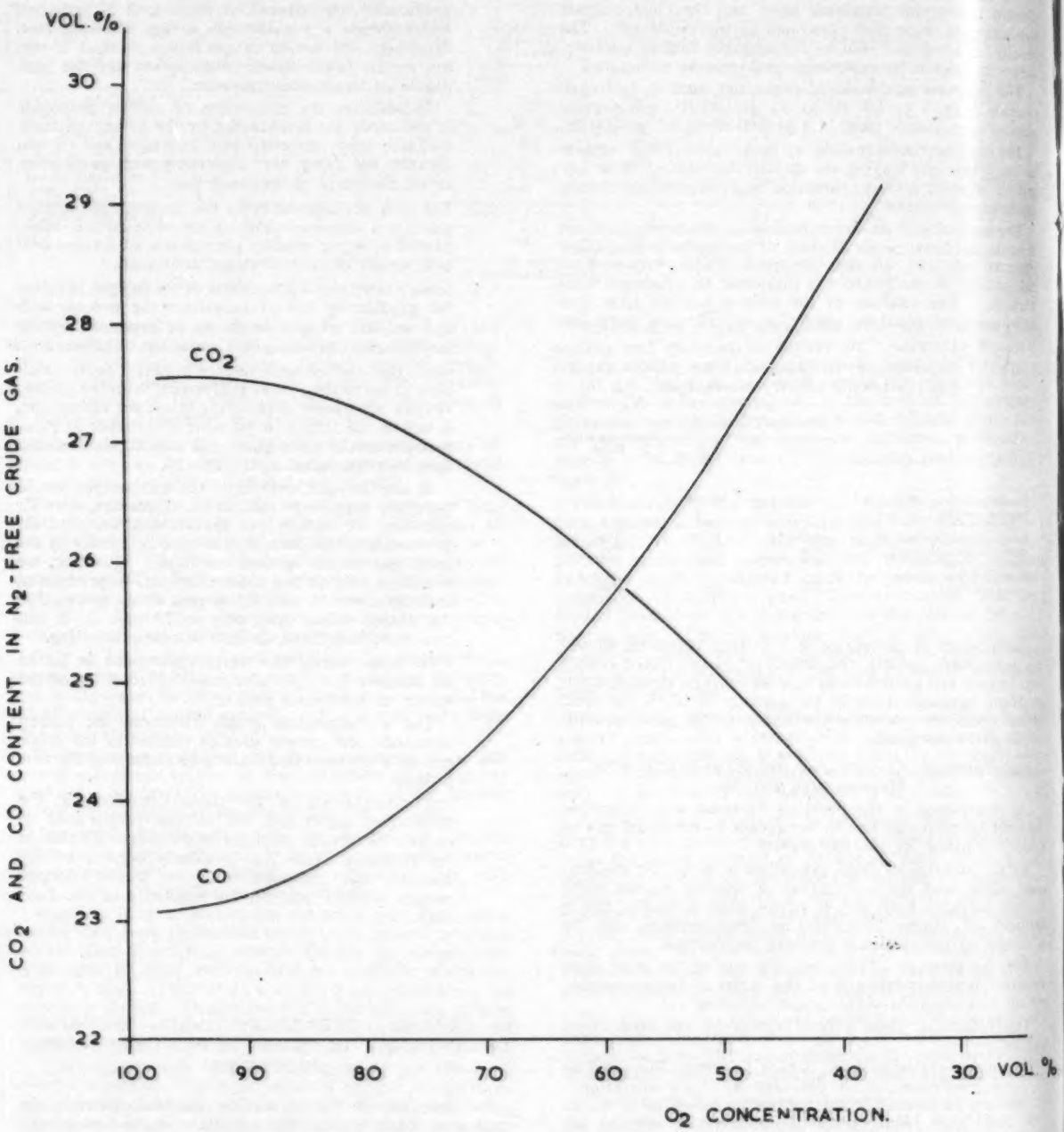
The accompanying graph illustrates the carbon monoxide and carbon dioxide content of the crude gas on a nitrogen-free basis when applying the new process.

Decomposition of the steam contained in the gasification agent and the volume proportions of carbon monoxide, methane and carbon dioxide in the produced crude gas obviously depend on the quantity and composition of the steam nitrogen oxygen mixture and on the reactivity of the feed coal.

VI FUTURE OPERATION AND ECONOMIC ADVANTAGES OF THE NEWLY DEVELOPED PROCESSES

As described in the preceding Sections, three main steps were taken towards the reduction of the cost of gas production. The first step was the introduction of "dry operation"; the second step was the development of crude-gas conversion; and the third step was the operation of the plant with oxygen-enriched air under specific operating conditions.

It would not be expedient to give any figures in respect of the savings reached, because these figures depend on the local cost of energy and labour. However, it may be said that the original production cost of the town gas has



Operation with Oxygen-enriched Air.

Changes in Carbon Monoxide and Carbon Dioxide Content of Crude Gas on a Nitrogen-free Basis.

been reduced by 20 per cent. This reduction is attributable to "dry operation", crude-gas conversion and operation with air addition in equal proportions. These considerable savings reduce the production cost of our gas, under full load conditions, to a price that is equal to that of the surplus gas from coke oven plants.

This reduction in the cost of the gas production does not take into account the better quality of the gas, namely, that it is now effectively detoxified.

In addition, we are able to introduce large quantities of natural gas into standard town gas without any thermal or thermo-catalytic reforming. We are therefore not faced with the necessity of installing new natural gas pipelines to consumers and of changing some of the consumers' equipment to the use of natural gas, which would require considerable capital investment.

These measures provide also great flexibility of the gasification plant and enable us to cope with peak requirements, without the peak gas being more expensive than ordinary coke oven gas.

This system of meeting peak-load requirements should also be of interest to Great Britain, even if natural gas should not become available, because refinery gas, mixtures of propane and butane or other low-boiling hydrocarbons can be used instead of natural gas for enrichment.

In future, we shall be able to supply 60 per cent of the thermal content of the town gas supply from unreformed natural gas.

Finally, it should be stressed that the present development is a matter of general interest. While six years ago natural gas was used to bring the Lurgi gas to town gas quality, the Lurgi gas will in future be used to bring the natural gas to town gas quality. Under the prevailing conditions in Germany, this may be regarded as a rather fortunate combination between the interests of coal and natural gas, which would otherwise enter into very strong competition.

In view of the fact that the gas demand is increasing at a faster rate than the demand for coke, and consequently the production of coke oven gas, the present development establishes a basis for meeting the high demand for gas that has to be expected in the future.

PRESENTATION, DISCUSSION AND REPLY

Presentation

Dr. H. Weittenhiller, presenting his paper, said:—When your President, Mr. H. S. Cheetham, asked me if I would be prepared to present a paper to The Institution of Gas Engineers on the high-pressure gasification of coal with oxygen, I readily accepted for two reasons; firstly, because in Germany it has not been forgotten that it was British engineers who developed the gas industry, and British engineers, your predecessors, who built the first gas works in Germany, in Hanover. I have, therefore, the honour of addressing an extremely knowledgeable audience.

My second reason for accepting this offer so readily, is that we have been interested in this problem for several years. You will know from your own experience how one likes to discuss with other experts things of common interest.

In the last few years, Britain has been concerned closely with the high-pressure gasification of coal, and two large plants are under construction, one of which has recently started operation, and, so far as I know or can judge over such a short period, it comes fully up to expectations.

It would, then, be a waste of time for me to deal with the theory and initial stages of development of the process in this paper. I have, therefore, considered only the practical experience we have acquired during almost six years of continuous operation, and the developments during this period. For this reason, I have also dispensed with any detailed description of the plant, especially since many of you have seen the plant and it has often been described in the literature.

As will be gathered from my paper, besides innumerable minor improvements, which cannot all be mentioned individually, three new steps have been taken to improve the high-pressure gasification process.

These three major steps are: firstly, the introduction of the so-called "dry method of operation", by which the original maximum plant output of 45 mill. ft^3/d was increased to the present 75 mill. ft^3/d; secondly, the conversion of hot crude gas with the result that, by the end of this year, production at Dorsten will be increased to 110 mill. ft^3/d without increasing the number of high-pressure gasifiers or enlarging the oxygen plant; thirdly, the addition of large quantities of air to the oxygen used for gasification, a measure that, combined with the conversion of crude gas mentioned above, will be of great economic value.

These three improvements have led to the gas being considerably cheaper than was predicted seven years ago, so that, under German conditions and normal operation of the plant, it can compete economically with coke oven gas.

If one takes the view that a carbon monoxide content of about 2 per cent renders the gas no longer toxic, then it can be said that detoxification is obtained without cost.

In my paper, I have not quoted any figures for production costs since, as will be appreciated, it is not easy to compare these, for in Britain quite different conditions prevail.

I should, however, be glad to quote estimated costs in Britain for those who are really interested, if they will give me the necessary figures on the costs of coal, energy, wages and materials. I should also need to know what capacity the plants are to have, what plant costs are estimated, and what capital charges would apply.

It will be gathered from my paper that there have been some very interesting developments, which can best be summarized by saying that, up to now, natural gas has been used to enrich the gas produced from the generators up to the standards for coke oven gas. In future, the new developments of process technique will enable us to use the gas produced for diluting natural gas to coke oven gas quality. This has the considerable advantage that, up to the outlet of the existing grid for the distribution of gas, no new pipes have to be laid, and the gas burners of consumers' appliances need not be altered which is otherwise extremely expensive.

From our point of view, we regard the new advances in technique that have been made in Dorsten as resulting in a happy combination of the interests of coal and coke oven gas and the natural gas industry.

In Britain it will, as far as I can see, work out in a similar manner.

One realizes that there is no source of natural gas in Britain, and we have, therefore, materially at the instigation of Mr. G. le B. Diamond, investigated means of utilizing liquid hydrocarbons, such as light distillate, for enriching by carburetting, instead of using natural gas. Preliminary tests have shown that this may easily be effected in conjunction with the catalysts used for the conversion of the crude gas.

At the beginning of June, 1961, tests will be carried out at Dorsten on a large scale, to enable the production of some definite data on these possibilities, and we have no doubt that

these tests will be successful. Light distillate or a similar material could then fulfil the same function in high-pressure gasification in Britain as natural gas does in Germany.

Perhaps—and with this I come to the end of this introduction of my Paper—there may still occur one or the other problem in connexion with high-pressure gasification with oxygen under the special circumstances obtaining in Britain. I am absolutely certain, however, that British gas enginers will brilliantly solve such problems. I wish you the best of success for your work.

Discussion

Mr. G. le B. Diamond, C.B.E. (Chairman, West Midlands Gas Board):—I am very pleased to have the honour of being invited to open this discussion on a most interesting paper—the more so because, over the years, I have enjoyed such cordial and happy relations with Dr. Weittenhiller and his staff at Dorsten. I have been there on innumerable occasions, and every time one comes away more and more impressed with the drive, the courage, the inventive genius and the enthusiasm of all at Dorsten under Dr. Weittenhiller's leadership.

I should like to pay my tribute to him for all the help and assistance given to the West Midlands Gas Board with the design of our Coleshill plant; it has been invaluable.

Early in the paper, Dr. Weittenhiller emphasizes that it deals with the practical operation and development of the high-pressure gasification process; and what a fascinating story it is. Much of it has come from good engineering thinking: "What is the objective we are aiming at?" "Why do we do it this way?" "Can it be done better?" Then followed the application of inventive genius and experimental work that resulted in the plant planned and worked out by Dr. Weittenhiller and his staff at Dorsten, in conjunction with the Lurgi Company, for the conversion of crude gas.

It will have been noticed that the plant for the conversion of crude gas has been placed betwen the waste-heat boiler and the heat exchanger. No more efficient method could be adopted, since it will not affect the recovery of heat in the waste-heat boiler, nor will it reduce the heat available for the regeneration of K_2CO_3, which follows in the train. The conversion reaction itself, being exothermic, replaces the latent heat of the steam actually consumed in the conversion.

It is well known that the catalyst used is a cobalt-molybdenum type as used for the benzoraffin process. This catalyst is, of course, resistant to sulphur compounds and requires the presence of sulphur to enable it to work at all, but is vulnerable to hydrocarbon droplets and to dust contamination. It would be interesting if Dr. Weittenhiller would enlarge on the method he has devised for eliminating the hydrocarbon droplets. We have a long experience in Britain of trying to eliminate hydrocarbon droplets by wire-drawing and the traversing of tortuous passages by the droplet-laden gas, but none of the systems devised would eliminate the passage of some droplets. Perhaps the pressure and the linear velocity of the gas in a Lurgi plant is sufficient to accomplish what is required.

It is a matter of speculation to consider what would happen if electrostatic precipitation were tried. There could be some interesting results from the electron bombardment of the molecule under pressure and in the presence of hydrogen.

Table 5, which records the improvement of quality of benzole by the catalyst for the conversion of crude gas is most impressive, and a better quality product seems to be obtained than from the normal benzoraffin plant. Some time ago, the West Midlands Gas Board came to the conclusion that we could not afford not to take advantage of the technique for the conversion of crude gas, for this is a major improvement in plant operation. It produces the desired degree of detoxification, the steam saving is of a high order, the organic sulphur is substantially reduced, there is an up-grading of by-products and a welcome reduction in the amount of effluent liquor produced, as well as the distinct possibility that the catalyst will also hydrogenate primary flash distillate for enriching purposes.

The improvements that have been introduced at Dorsten have resulted in a much larger increase in the gas volume passing through the plant, for the output has been stepped up by no less than 60 per cent. Unless the plant was originally overdesigned, one would have thought that there would have been trouble with the connexions between the vessels being undersized and even the vessels themselves. Moreover, Dr. Weittenhiller has not enlightened us on the method he proposes to adopt to remove the hydrogen sulphide from the unpurified gas when the plant for converting crude gas is working, for the carbon dioxide will then be no less than 37·1 per cent. It is well known that the Alkazid lye takes up appreciably more hydrogen sulphide with a low carbon dioxide: hydrogen sulphide ratio.

In our investigation, we have found that it will be necessary to supplement the lye wash in the Alkazid plant at Coleshill, and the temperature of the lye will have to be reduced in times of hot weather to about 22°C in the final wash, if the hydrogen sulphide left for extraction by the tower purifiers is to be reduced to manageable proportions.

The proposal to use oxygen-enriched air is one that has been explored, at any rate on paper, in Britain but no one has really tried it on any scale, and certainly not for pressure gas production. It is bound to have far-reaching results, and is made possible by the increasing availability of natural gas. Whether the economics will remain valid by the use of hydrocarbon enrichers that are available to the gas industry in Britain remains to be seen. Be that as it may, oxygen-enriched air is likely to have a beneficial effect at the bottom of the fuel bed, since it is most probable that the combustion will be slightly retarded and there will be a better control over the reaction and less steam used. It should be remembered that such a vast quantity of steam is used in order to keep the bottom of the grate cool and keep a good depth of ashes there. Moreover, the nitrogen introduced will supersede the nitrogen that has to be added by compression for ballasting purposes. With the use of oxygen-enriched air, it must be expected that there will be less waste heat to recover at the outlet of the generator. This could upset the balance of heat input to the plant as between high-pressure and low-pressure steam, so that, in the end, the net economic saving might be less than anticipated.

The disposal of effluent is a very serious problem in Britain, for the legislation on the subject is already onerous, and more is to come. To dephenolate the liquor and to remove the free ammonia is not enough. Even if biological-purification plant is put down to deal solely with Lurgi effluent, the degree of purification effected would not meet the requirements of certain river boards in those areas where it would seem most desirable to put more Lurgi plant.

From some rough calculations I have made, it would seem that, under the conditions of dry operation and conversion of crude gas, the amount of effluent liquor for disposal will still be appreciably more than the liquor produced by the conventional carbonizing process. It will be remembered that, before Dr. Weittenhiller effected these improvements, the amount of liquor for disposal from a Lurgi plant amounted to as much as 200 gal/ton of coal gasified. Even if some satisfactory method could be found to reduce the toxicity of the effluent by a biological oxidation without the addition of domestic sewage, it might prove to be a costly method of disposal because of the need for large quantities of water for dilution and the addition of nutrients to keep the bacterial life going.

A word or two must now be said in conclusion about enriching. Obviously, imported methane would be, and might well be, the proper hydrocarbon additive for the Coleshill plant. It has become quite clear to me, however, that, with the best will in the world, it is most unlikely that imported methane could be made available by the time the Coleshill plant will be ready. The alternative is butane, or propane, or a mixture of both, but, as everyone knows, transport and the storage of these gases in quantity is a very costly matter indeed, and one that could not be contemplated for so short a time as to bridge the gap between the starting of the Coleshill plant and the availability of methane. Something else has had to be thought of, and I suggested to Dr. Weittenhiller that his conversion plant for raw gas might provide an ideal reaction vessel for hydrogenating primary flash distillate for enriching purposes. He has already said that preliminary laboratory tests have shown that this may be done in conjunction with the catalyst he is using, and further tests are to be made on the plant in the next few months. It is very much to be hoped that the larger scale tests on the Dorsten pilot plant will prove

this idea to be practicable. The storage of primary flash distillate is more easily arranged and far less costly than the storage of some other hydrocarbons, and this might prove to be the ideal solution for the intervening period at Coleshill. It has been said that primary flash distillate is in short supply, but the West Midlands Gas Board has not found this to be so, and has entered into contracts to cover the likely needs of the Board for some years.

Dr. Weittenhiller mentions the production of carbon dioxide as a saleable by-product. The West Midlands Gas Board has taken advantage of his experience, and the negotiations for the sale of the Coleshill carbon dioxide are in an advanced stage. To begin with, the West Midlands Gas Board expects to be able to dispose of from 20,000 to 30,000 tons/a in the early years; fortunately, the use of carbon dioxide is expanding so fast that the Board does not anticipate any difficulty in selling future production in view of the situation of the West Midlands plant.

In 1952, when the Board was originally planning the Lurgi plant for the West Midlands, it looked upon it essentially as a baseload plant, and, at that time, industry was working on Saturdays. The drop in the industrial load over the week-end, in consequence of the two days' holiday, has now become something of a problem, and it is very welcome to note how flexible the Lurgi plant is in the matter of regulating supply against demand.

The West Midlands Gas Board is greatly indebted to Dr. Weittenhiller for the work he is doing for us in this connexion, and I congratulate him on his paper.

Mr. Sydney Smith, C.B.E. (Chairman, The Scottish Gas Board):—This paper by Dr. Weittenhiller must certainly be classed as one of the most valuable ever presented to a meeting of The Institution of Gas Engineers, and I should like sincerely to add my congratulations and thanks to the Author.

Dr. Weittenhiller deals first with improvements carried out in the operation of the Dorsten plant as initially installed, and then with two aspects of development for the future production of larger quantities of gas at lower cost; and it is interesting to consider these three aspects separately in relation to the Lurgi high-pressure gasification plant at Westfield.

These remarks will show that, as a result on the one hand of parallel, but independent, developments of thought, and, on the other hand, of the most valuable interchange of information, the Westfield plant was designed and built very much along the lines advocated by the Author in his paper.

I should like to take this opportunity publicly to acknowledge my profound indebtedness to Dr. Weittenhiller and his staff at Dorsten; and, indeed, to Mr. P. Etienne Rousseau and his staff at Sasou; and Dr. R. S. Andrews and his staff at Morwell, for the vast amount of information and advice freely and willingly given to The Scottish Gas Board over the past three or four years.

The Author describes various changes made in the operation of the gasifiers, which have resulted in a considerable reduction in steam used and a larger output per gasifier. It is of interest that the Westfield plant was designed to incorporate most of the improvements described in the paper, and the results now being achieved are very similar, as regards output per gasifier and steam consumption, to those now reported.

When one compares the performance of the earlier type of gasifier with the results now obtainable from the improved design, it is evident that we have entered a new era in the economy of town gas production from coal. In Section III of his paper, Dr. Weittenhiller shows how the output of the Dorsten installation has increased from the original design figure of 46 mill. ft³/d at 450 Btu/ft³, to 75 mill. ft³/d at the same calorific value.

Assuming that five gasifiers are in operation, with one as standby, this means that each gasifier is now capable of providing 15 mill. ft³/d of town gas; but it is noted that the town gas includes approximately 15 per cent of natural gas, or about 2·25 mill. ft³/d for each gasifier. It would appear, therefore, that each gasifier at maximum output can produce approximately 12·75 mill. ft³/d of purified Lurgi gas at a calorific value of about 400 Btu/ft³.

The gasifiers at Westfield are similar in size to those at Dorsten, and each one has a nominal capacity of 7·5 mill. ft³/d. The plant has been in operation since 27th December, 1960; naturally, we experienced initially our due share of teething troubles, but at Stage I the works is now running at a steady rate of around 15 mill. ft³/d of town gas. The performance of the gasifiers has been excellent, and although for the time being we have no intention, nor indeed is there any need, to aim for maximum outputs, we have already found it quite easy to achieve an output from each gasifier of almost 11 mill. ft³/d of purified Lurgi gas at a calorific value of 410 Btu/ft³, containing approximately 4 per cent of inerts.

As I have said: this output has been obtained quite easily, and compares with the figure of 12·75 mill. ft³/d of purified Lurgi gas per gasifier obtained at Dorsten. I have no doubt at all that, in due course, we shall be able to reach the Dorsten figure if it is necessary to do so.

The design capacity for Stage II of Westfield is 30 mill. ft³/d of town gas at a calorific value of 450 Btu/ft³; but it is already evident that, in practice, we shall be able easily to exceed this figure by some 20 or 30 per cent; and, as our estimate of production costs were based on a gasifier capacity of 7·5 mill. ft³/d, the extra output will be available at a marginal cost, which will mean a very substantial betterment.

The steam and oxygen requirements are also appreciably lower than we expected: steam is slightly less than 6 lb/100 ft³ of purified Lurgi gas, which is almost the same as that quoted in the paper, when allowance is made for the addition of natural gas; and oxygen consumption is of the order of 19 ft³/100 ft³ of purified gas.

For future development, Dr. Weittenhiller first describes the very interesting and important development of the crude gas carbon monoxide conversion process, also known as the "raw gas" or "hot gas" conversion process, which will allow the Dorsten plant to make a lighter gas and thus allow as ballast larger quantities of natural gas and nitrogen to be added for distribution as town gas. The other development is the use of oxygen-enriched air instead of oxygen.

At the time the Westfield plant was conceived, the process for the conversion of crude gas was not available, but conventional cold gas conversion was included for Stage II of the plant, which is now under construction. This was done primarily to reduce carbon monoxide, but also to take full advantage of hydrocarbon enrichment very much on the lines described in the paper. It was necessary to make absolutely certain that the ordinary conversion catalyst would stand up to any constituent of the gas, and the necessary precautions to prevent fouling were taken care of in the design.

As a result of this wonderful exchange of information, which does not seem to know any national boundaries, The Scottish Gas Board learnt about the new Dorsten process for the conversion of crude gas early enough to make it possible for this type of conversion process to be incorporated at Westfield; and this is being done. This process has a number of advantages over the conventional process, including substantial economy in steam and, as described in the paper, a significant improvement in the quality of by-products. The Scottish Gas Board is also making provision, during construction of the plant for the conversion of crude gas, for introducing enrichment with primary flash distillate should the experiments at Dorsten turn out to be successful; and I have no doubt they will.

I have mentioned the lighter gas produced and the increased output at Dorsten as a result of the use of additional ballast gases; and the primary consideration of detoxification in introducing carbon monoxide conversion at Westfield. It would be interesting to know if Dr. Weittenhiller considers carbon monoxide reduction to be worth while for the Dorsten plant, purely from the detoxification point of view.

With regard to the use of oxygen-enriched air instead of oxygen, this certainly has all the advantages mentioned in detail in the paper, but it does require the handling of the additional nitrogen throughout the gas treatment and purification stream. In an existing installation this might overload these units, whilst for any new plant a careful economic assessment would be necessary.

In this connexion, it is worth noting that the production of 90 or 95 per cent-purity oxygen requires less power per unit of pure oxygen made, than that for 98 per cent purity;

and, in the design for the Westfield plant, an important departure from previous practice was actually carried out by the use of oxygen of 95 per cent purity. Dr. Weittenhiller's paper tends to indicate that this was a step in the right direction.

I should like to conclude by making a general reference to the flexibility of output obtainable from the Lurgi gasifiers. The Author has pointed out the value of operating Dorsten on a flexible-output basis, in order to allow large quantities of cheap, base-load coke oven gas to be absorbed into the Ruhr gas grid. The capital costs of a Lurgi plant are high, and flexibility downwards can be obtained only at the expense of an increased proportion of overheads. At Westfield, it is our intention to operate the plant at the highest possible load factor, and to use carburetted water gas and refinery gas reforming units to provide the necessary flexibility to meet variations in demand in the grid area. In a few years' time, we shall possibly have the additional support in this connexion from the use of our Cousland natural gas well for underground storage purposes.

The paper is packed full of nourishing meat; and for me and for the Board's staff, it becomes a matter of keen interest and future enjoyment to anticipate the developments and improvements that the years ahead will surely bring to the Lurgi pressure-gasification process.

Mr. H. D. Greenwood (Assistant Director-General of Carbonization, National Coal Board):—This paper by Dr. Weittenhiller is very opportune in view of the discussions that are current about the relative costs of making gas by the Lurgi process as compared with gas made from other raw materials. Apart from this, however, it is the first time that we have had in this country a paper describing the Dorsten Lurgi plant and the work Dr. Weittenhiller and his colleagues have been carrying out over the past six years. I well remember being told something of the plans of Ruhrgas to erect a Lurgi plant, and was astonished to find that the project had been completed in 13 months. (British contractors please take note!) Since the plant went to work in 1955, there have been, apart from the various improvements in details, three major developments that are described in the paper. Firstly, the reduction in the steam:oxygen ratio and increased coal throughput; secondly, the development of the carbon monoxide conversion process using a catalyst that will operate on the hot crude gas; thirdly, the use of oxygen-enriched air in place of high-purity oxygen.

There is, of course, nothing particularly novel about any of these developments, but the important point is that at Dorsten they have been tried out on the large scale and shown to be practicable and economic.

The carbon monoxide shift system so far has, I agree, only worked on pilot-plant scale, but I am told that it is now to be installed to treat the gas from one of the main gas streams. We have heard that it is to be installed both at Westfield and Coleshill.

I am not clear whether the use of enriched air will now be the practice on the whole plant, and I should be interested to learn whether this is proposed.

Dr. Weittenhiller has said that these improvements have resulted in a reduction in gas production cost of 20 per cent, in approximately equal proportion by each of the three. One cannot, of course, apply this figure directly to costs in this country, since the relative cost of coal and capital differ very considerably from those at Dorsten; for example, the cost of coal at Dorsten is about 50 per cent higher than the cost of small coal to a Lurgi plant in this country. On the other hand, the capital cost of the Dorsten plant, built six years ago, is very much below costs of comparable plants today. But despite the high cost of coal, Steinkohlengas is making Lurgi gas as cheaply as coke oven gas, its main and traditional source of gas. This has, I believe, always been the objective; Steinkohlengas must be very happy to have achieved it. If we can match its technical results we might, I think, also claim to make enriched Lurgi gas as cheaply as coke oven gas, which is a long way below the order of costs given in the Report of the Wilson Committee.

Dorsten has the advantage of cheap natural gas for enrichment, but I suggest that we could obtain suitable high calorific value gas for enrichment from light distillates at an equally attractive cost. Of course, the coal industry still hopes that Dr. F. J. Dent will one day present a process for making a rich gas by coal hydrogenation as cheaply as from petroleum products. In the meantime, however, there are several possible ways of converting light naphthas into rich gas. Dr. Dent proposed, some time ago, two methods, one catalytic and one using a fluidized bed of coke. However, nothing has been heard about these for some years. Dr. Weittenhiller and Mr. Diamond have mentioned the possibility of injecting light distillate into the gas before the carbon monoxide catalyst. I gather they have been successful.

Enrichment with varying proportions of natural or reformed L.P.D. gas plus dilution with nitrogen to give the required combustion characteristics gives more flexibility in output. The range of output of the plant can thus be increased without alteration in coal throughput.

This brings one to the flexibility of the Lurgi process, to which Dr. Weittenhiller devotes some attention. He points out that a ratio of 4:1 is possible between maximum gas output with carbon monoxide conversion and minimum output without carbon monoxide conversion, and that it is the practice to vary the output of the plant to meet the seasonal change in gas consumption. In summer, only two out of the six generators are in use. I should be interested to know what is the average load factor of the plant over a 12-month period.

The gas output of the plant can be varied at short notice by operating different numbers of generators, and also, by some 20 per cent, by varying the quantity of enrichment gas. Two types of town gas are given in the paper; can these be taken as representing the extent to which output can be varied under German conditions?

Under the conditions in the Ruhr, where the bulk of the supply comes from coke ovens, I can understand that peak-load gas can be made as cheaply from the Lurgi plant as by any other means.

If town gas can be made by the Lurgi process with the latest improvements for, say 8½*d.*/ therm, which I think may be possible on large units, then the cost of town gas made by the Lurgi process when operated to meet peak loads may well be competitive with the alternative of running the Lurgi plant on base-load and providing the peak load by a separate oil-gasification plant.

The important point is that Lurgi gas is a means of providing a low-gravity gas for mixing with high-gravity rich gas obtained by oil gasification. This combination may provide the break-through in gas costs for which the gas industry is seeking.

Dr. Weittenhiller has told about ways of improving the Lurgi process; some of these improvements have already been included in studies that have been made in this country, but there are still a number of possible ways of improving the process apart from those already mentioned, and a study of the oxygen, steam and power production costs will be found to be quite rewarding. I hope that it may soon be possible to try out new ideas on plants in this country; in the meantime, I am sure we can look to Dr. Weittenhiller and his colleagues at Dorsten for assistance in putting new ideas to the test.

May I conclude by congratulating Dr. Weittenhiller not only on his paper, but on his direction of the Dorsten Lurgi plant since its inception, and for his foresight, energy and enthusiasm, in conjunction with the Lurgi Company, in developing and improving this process.

Dr. F. J. Dent, O.B.E. (Director of Research, Midlands Research Station, The Gas Council):—It is a pleasure to add my tribute to Dr. Weittenhiller for his splendid paper. It is a mine of information and a wonderful record of achievement.

The whole story of Dorsten is a lesson in process development, erection and operation, beginning as it did with the pilot plant work at Oberhausen and culminating with this flexible installation having a maximum output of 112 mill. ft³/d. The project was pushed forward in a period that has been one of unparalleled fluctuations in the fuel situation. The changing circumstances might well have been taken as an excuse for caution. Instead, with a most courageous approach, they have been turned to good account, resulting in a considerable increase in the usefulness of the plant and two important process developments.

It has been evident that a successful application of the Lurgi process, with its large excess of process steam, would involve an exercise in waste-heat utilization, and the two developments that Dr. Weittenhiller describes—the use of the undecomposed steam for the conversion of carbon monoxide in the crude gas, and the closely related use of oxygen-enriched air—are very much in the direction we hoped that developments would occur. Our interest in converting carbon monoxide to hydrogen with steam is as old as our interest in hydrogenation reactions, and for long we have cast covetous eyes on the undecomposed steam leaving the gasifier. The attendant advantages of ballasting the gas with nitrogen became apparent as soon as pressure first made the enriching therm the cheaper therm.

The pilot pressure gasifier at Solihull could never be operated sufficiently continuously for us to study the catalysis of conversion in the crude gas, and we could not foresee the interesting upgrading of the by-products that accompanies it, but we were able to investigate the ballasting of the gas by using enriched air for gasification. Our results were obtained at 25 atmospheres by mixing air with the oxygen and then adjusting the steam supply to maintain the same maximum temperature in the fuel bed, as shown by thermocouples. They indicated that, for conditions in which the final calorific value was to be reached by butane addition (and it does depend upon the method of raising the calorific value), the use of enriched air would reduce the consumption of oxygen per therm by about 35 per cent, and the consumption of steam by about 25 per cent. These are in reasonable agreement with Dr. Weittenhiller's data from a large-scale test. It is very satisfactory indeed, and the effort at Dorsten commands our very sincere congratulations.

A feature of Dr. Weittenhiller's paper is the acceptance of the operation of the Lurgi process under variable load conditions, and it calls for careful consideration since it bears directly on our desire to expand into the space heating load.

At Dorsten, it has been appreciated from the outset that operation in conjunction with coke ovens would require the gasification plant to be on variable load, and, accordingly, it was most admirably sited, at the mine, and adjacent to a power station, so that graded coal, steam, power and compressed air for oxygen production were freely available. Capital charges were minimized in this way. Then, there have been these further process developments, benefiting from an indigenous methane supply and enabling Dr. Weittenhiller to make the remarkable claim of producing peak-load gas as cheaply as ordinary coke oven gas; and it is a highly pure, non-toxic gas.

Obviously of major importance, it will prompt the question how a similar flexibility is to be obtained in Britain, where, in certain directions, conditions are sharply different from those in Germany. In particular, we have not yet found a cheap indigenous source of methane. While, as a result, we are striving for a lower cost of gas production by operating steadily at maximum output, how can operation at reduced output be entertained?

It may be possible if, whilst maintaining the gasifiers at full load, output is varied by alternating between different methods of enrichment, and there are several methods, at various stages of development, to choose from. At one extreme, for minimum output, there is catalytic methane synthesis from carbon monoxide, which adds nothing to the gas yield; and coal hydrogenation, which adds a little; both of them give an all-coal process. Then there is oil hydrogenation, which adds more, and next, ready-made enrichers, such as butane, refinery gas and, particularly, methane, which add still more. Finally, there is light distillate, which, after simple reforming, increases the gas yield most of all.

The essential difference between the methods in this series is that there is a progressive diminution in the effective calorific value of the enricher so that more is used in reaching a given calorific value in the final gas. In consequence, the output of the plant is greater and, within the range, it can be increased 2½ times, without altering the rate of coal gasification, solely by changing the enricher to methane or distillate. The increase is still greater if advantage is taken of the fact that, at a higher output, more air can be admixed with the oxygen supply, with the possibility of increasing the basic rate of coal gasification as well.

When a high output is obtained by using an enricher of lower calorific value the enricher contributes a considerable proportion of the gas yield, but capital charges on the gasification plant are such that the overall cost of the gas is reduced thereby. When the maximum output is not required, however, and it becomes a question of minimizing operating costs, there is the fact that, at least until there is piped natural gas to this country, the cost of the coal per therm of gas made from coal is likely to be materially less than the cost per therm of enrichers such as methane and butane. Off peak load, therefore, operating costs will be reduced by changing the method of enrichment so as to approach more closely to an all-coal process. This is especially so in view of the process developments at Dorsten, both of which have reduced the cost of the therm from coal.

To illustrate the effect of changing the method of enrichment, let us select two from the list, namely, the hydrogenation of light distillate and the reforming of light distillate, both in an advanced pilot-plant stage. They do not fully exploit the range of output available, but they fit nicely from an operational point of view and are probably capable of giving all the load variation required. The hydrogenation method is justified by the cost of the enricher being reduced by a by-product of benzene, and the effective calorific value is high, in excess of 2,500 Btu/ft^3. Reforming the distillate, a simple autothermic reaction with steam, is justified by giving the maximum output, and the effective calorific value is lower at 850 Btu/ft^3.

When these two methods are used in the production of a town gas of standard quality and 500 Btu/ft^3, the output with reforming will be as much as three times that obtained with hydrogenation. This will be due to the addition of more oxygen as air increasing the rate of coal gasification 1·5 times, and to the gas production from distillate increasing five times. The ratio of the therms from oil to therms from coal will be 0·6 at the low output, and 2·0 at the high one.

There is a question, however, whether the gasifiers can be operated at a sufficiently high output to fully reflect the air addition in an increased rate of coal gasification. Dr. Weittenhiller hesitates to say so, and, in discussing the use of enriched air, he indicates that the effect is to give rise to reserve capacity in the oxygen plant. But there is something paradoxical in this reserve becoming available by air being introduced at a time of high gas output, although the reserve could be used, as in Dr. Weittenhiller's case, for example, to produce more gas in a hydrocarbon reformer.

To us, however, oxygen is pre-eminently the medium for liberating heat for steam decomposition in a bed of coal, and, therefore, I would ask Dr. Weittenhiller, if the Lurgi gasifiers cannot at present accommodate the additional oxygen supplied as air, what is preventing them doing so? Is it the size of the connexions, as mentioned by Mr. Diamond? Is it the carry-over of coal dust? Is it conditions in the fuel bed, or the ability to lock hopper the coal supply. Could any restrictions due to the gasifiers or, indeed, to any other plant units, be pushed back by raising the pressure a little. One would like to think that the output of the gasifiers was being determined by the fuel-bed reactions so that a higher output could always be obtained at some sacrifice of reaction efficiency, if need be.

The conclusions that can safely be drawn from Dr. Weittenhiller's paper is that an installation of pressure gasifiers is essentially flexible, and this should be taken account of in an economic assessment. But considerations are affected by the potentialities of yet another recent development, the storage of gas underground.

I shall end by asking Dr. Weittenhiller to comment further on the undoubtedly important flexibility he has achieved in plant operation in relation to underground storage, since this is already available in Germany.

Mr. J. E. Davis, O.B.E. (Chief Technical Officer, South Eastern Gas Board):—I, too, should like to add my thanks to Dr. Weittenhiller and his colleagues at Dorsten because I, too, am one of those people who benefited so much from visits to them, from their hospitality and the knowledge of what they are doing.

I do not propose to make many technical points, because I really think we have quite a lot to digest already, particularly from Dr. Dent, but I would point out that it is now some 30 years since the pioneer work of Dr. Drawe and the subsequent developmental work of the Lurgi Company aroused a great deal of interest among some people. It showed how the economics of gas manufacture from coal might be freed from the adverse effects of a fluctuating market for secondary products. There was interest; there was also apprehension; there was fear about the safety and reliability of high-pressure plant. There were doubts about oxygen plant and the heavy consumption of oxygen. The process was known to be selective in coals. It required an inordinate amount of steam to prevent the fusion of the ash. A high proportion of this steam was undecomposed and gave rise to difficult effluent problems. The output of a generator was low; purification was difficult. Fortunately, there were men—and one must include the late Kurt Traenckner—who saw that the prizes that might be gained by development of the process were worth taking risks for. The risks were taken. Dorsten was started, and the paper Dr. Weittenhiller has written shows how, one by one, disadvantages which were foreseen and were quite real, and difficulties that were quite real, were overcome.

In respect of reliability, we have these figures of 300 days/a between overhauls of the gasification oxygen plant, and a maximum maintenance period of four weeks/a being quite sufficient. There is increased output and reduction in steam consumption. None of these things could have taken place if someone had not built a plant and faced all the difficulties and come through them. It is for that courage, for that persistence, as well as for the hospitality and free exchange of knowledge, that we have to thank the Author and his colleagues today.

There is an aspect of this work, however, that is really most exciting and of great promise. When it started, by comparison with coal carbonization by the known methods, it looked as though it were going to be another way of making the same sort of gas from the same sort of raw material. In the discussion this morning, apart from anything else, one sees the enormous changes that have taken place in the availability of so many raw materials. In Germany, natural gas; in most places, petroleum products.

We have come to think quite differently about the question of carbon monoxide conversion. We should all like to do it, but feel we cannot afford to. But when one accepts this modern idea of blending hydrogen with a ballasting gas, and an enriching hydrocarbon gas to give a specification town gas, one begins to see that there are other advantages in the conversion of carbon monoxide to hydrogen, apart from detoxification. It provides a light element, it provides enormous flexibility in the kind of enricher one adds, in the proportion of enricher and the proportion of ballast gas. It is giving us the ability to play tunes upon coal- and oil-gasification plant. What started as being an attempt to make gas without making coke has now opened up a vast range of possibilities, and the biggest problem is to know which to choose first and how to place them according to economic merit.

Mr. K. W. Francombe (Whessoe, Limited, Darlington):—I should like to ask Dr. Weittenhiller two questions. I must precede them with a few remarks. My reading of the Wilson Report was that the original Lurgi system, based on what, I presume, was the evidence given to that Committee, was probably an interim measure pending the development of the ultimate, namely, the slagging gasifier which, the Wilson Report suggested, would take another five years to develop, and which would cost £1 mill. or £2 mill. in the course of its further development.

With the quite sensational developments outlined by Dr. Weittenhiller in his paper, it occurs to me that now this newly developed Lurgi system, embodying these three new features—dry-bed operation, crude hot gas carbon monoxide conversion and the use of oxygen-enriched air—might conceivably make this system competitive with what is expected from the slagging gasifier. Therefore, I should like to ask Dr. Weittenhiller whether, in his opinion, this is so.

The second question I should like to ask is probably the "64,000-dollar" question. I think that the new catalyst that has been developed for use on the hot crude saturated gas under the really quite appalling conditions that the gas will now have to be treated in the carbon monoxide converter, would be a most valuable tool in many other applications of carbon monoxide conversion to hydrogen. I should like to know whether this catalyst is generally available, or whether its composition is a very closely guarded secret.

The last point I should like to make is in comment on a remark, made by Mr. Diamond, regarding the feasibility of using electrical precipitation as a means of purifying the gas before it reaches the hot crude carbon monoxide converter. All I can say is that it would be extremely difficult to operate a precipitator under these conditions, mainly owing to the extremely high pressure of the gas. Such high-pressure gas calls for enormously high voltages to initiate a corona discharge, and I feel that the cost of an electrical precipitator to operate under these extremely difficult conditions might well prove to be prohibitive.

Dr. A. E. Haffner (Southern Gas Board):—This paper is primarily about pressure gasification of solids, but tucked away in it are about eight lines devoted to the high-pressure reforming of natural gas. This little sentence carries with it a good deal of interest and hope for those Boards that are so remote from sources of coal suitable for pressure gasification that the coal for such a purpose would either have to cost nothing or the transport would have to cost nothing. Could we have a little more information than is given by the eight lines devoted to the high-pressure gas-reforming plant?

The President (Mr. H. S. Cheetham):—This is as far as we can go with the discussion. Dr. Weittenhiller must be highly gratified that there has been such an interesting discussion on his paper. He has a large number of questions to answer. I hope that it will not deter him from giving the Institution another paper in due course.

Written Reply

The **Author,** in reply, wrote:—

(A) MR. G. LE B. DIAMOND—

(1) *Droplet separation*

The removal of organic and inorganic droplets from the crude gas is carried out as follows:—

The crude gas is passed from a settling chamber through tortuous passages from which the precipitated droplets can run down into a sump. A special method has been developed to evaporate lower-boiling components from any droplets not precipitated, so that residual droplets agglomerate; the drops remain sufficiently fluid to be collected in a second-stage removal unit.

(2) *Electrostatic precipitation*

This is theoretically possible and would be attractive but for two major difficulties.

(*a*) Since the plant is under a pressure of about 300 lb/in², it would be necessary to use very high voltages.

(*b*) It is possible, although unlikely, that oxygen may be present in the crude gas, so that an explosion with unforeseeable consequences could be caused.

I should like to add that the Lurgi Company has for some time been investigating this subject, and some experimental work has been started.

(3) *Higher CO_2:H_2S Ratio after crude gas conversion, and its effect on the Alkazid plant*

A careful study of practical data together with theoretical considerations has led to the conclusion that the Alkazid wash is still the most economical process for removing hydrogen sulphide from sour gas even when the carbon dioxide: hydrogen sulphide ratio is high. It is, of course, necessary to keep the lye temperature below certain limits.

(B) MR. SYDNEY SMITH—

(1) *Is the reduction of the CO content at Dorsten worth while purely from a detoxification point of view?*

The crude-gas conversion plant at Dorsten will require no additional labour and no additional steam above that used in

the gasification plant. These factors represent about 40 per cent of the cost of clean-gas conversion. The only expenditure that is required for crude-gas conversion is the capital cost.

Assuming that it were not possible to use oxygen-enriched air nor to increase the town gas supply by 50 per cent using a mixture of equal volumes of methane and nitrogen, it would then be necessary to cover the capital charges by the profit derived from the cracking and refining of the hydrocarbons contained in the crude gas, and the saving obtained from treatment of the reduced liquor volume. It is not yet possible to say definitely whether the capital cost of carbon monoxide conversion plant will be covered in this way; only large-scale operation can provide a conclusive answer.

I should also like to refer to the work of Mr. Jordi, Director of the Basle Gas Works.[1] He found that a reduction of the organic sulphur, hydrogen cyanide and nitrous oxide contents of the gas led to considerable savings in burner jet maintenance in the district.

For us this is, however, of secondary importance since our main problem is to increase the use of natural gas and to operate our plant with oxygen-enriched air. The savings thus achieved far exceed the cost of the installation and we accept detoxification as a pleasant cost-free side effect.

(2) *Use of oxygen-enriched air as gasifying agent and its effect on purification*

Normally, all stages of the purification train are designed to have some spare capacity and for part-load operation the use of oxygen-enriched air does not cause any difficulty. At maximum load, however, it may be necessary to add part of the ballast nitrogen to the gas after purification due to limitations in the capacity of the purification plant.

For new plant, we have concluded that it would be most economic for the capacity of purification plant to be such that full use can be made of oxygen-enriched air as gasification agent. It is not possible here to present a detailed assessment of the consequent increase in capital cost of purification plant, which is in fact marginal.

(C) MR. H. D. GREENWOOD—

It is correct that the idea of crude-gas conversion is not a new one, as Elsworth and Williams obtained a patent in 1907 for the conversion of gases containing hydrocarbon vapours, and Herglotz took out a patent in 1931 describing the conversion of tar-laden crude gas.

The importance of the development at Dorsten is that for the first time a way has been found to convert hot crude gas containing various impurities without the addition of steam. Optimum conditions for the reaction were found by prolonged experiments in a pilot plant. The same applies to operation with oxygen-enriched air for the production of town or synthesis gas.

It is intended to operate the whole plant with oxygen-enriched air as soon as the crude-gas conversion plant is in full use. The load factor of the Dorsten plant is approximately 55 per cent.

(D) DR. F. J. DENT—

(1) *Where is the upper limit of production in the gasifier at which oxygen-enriched air can be used?*

Experiments at Dorsten have shown that, even at full load, oxygen-enriched air can be used up to the quantity of ballast nitrogen required in the town gas. The following example will make this clear:—

Normal Operation

Maximum oxygen requirement per gasifier 104,000 ft³/h.

Operation with oxygen-enriched air

Oxygen from Linde plant	74,000 ft³/h.
Oxygen in Air	30,000 ft³/h.
Nitrogen in air	119,000 ft³/h.

The gas production in therms per unit oxygen is maintained and the total volume of gas, plus high-pressure steam, passing through the gasifier is not increased, since the volume of steam saved exceeds the volume of extra nitrogen. Assuming that the plant has not been designed initially for operation with oxygen-enriched air, it may still be possible to extend this technique to the whole plant at peak-load periods, dependent on the pressure drop in the pipelines and the capacity of the purifying train.

The capacity of the Dorsten works is at present limited by the capacity of the oxygen plant. Owing to the special method of methane reforming used at Dorsten, it appears best to use only pure oxygen and not air in this process. Using enriched air for Lurgi gasification increases the maximum amount of oxygen available from the oxygen plant by the oxygen content of the added air.

(2) *What limits the maximum capacity of the gasifier?*

With "upwards" gasification, there are essentially the follow ing two limits:—

(*a*) The gas velocity in the gasifier at which the carry-over of coal dust becomes serious.

(*b*) The cross-section of the gas connexion to the wash cooler.

"Downwards" gasification, in which the fuel on top of the gasifier is ignited, allowing the zone of reaction to travel down during operation, has been the subject of intense theoretical considerations and calculation. The idea is, however, still considered to be too uncertain for practical operation.

(3) *Pressure gasification and underground storage*

Gas is stored underground during the week-end and taken out of store during the week, particularly in winter. Underground storage also reduces the load on the grid if it can be placed near the centre of consumption. Strategic placing of underground storage is very useful in case of grid failure.

(E) MR. K. W. FRANCOMBE—

(1) *Is the Lurgi pressure gasification with crude-gas conversion and using oxygen-enriched air economically competitive with a slagging gasifier?*

It is, of course, at the present state of development not possible to make accurate predictions to what degree a slagging gasifier may be competitive with the improved Lurgi process. One would also have to consider whether crude-gas conversion and use of enriched air could be applied to a slagging gasifier.

(2) *Is the catalyst used in crude-gas conversion generally available and is its composition known?*

The composition of the catalyst is no secret and the process itself and its optimum conditions under normal and elevated pressures are all covered by patents. There is, of course, a certain "know-how" in the application of this process to practical plant.

(F) DR. A. E. HAFFNER—

Information on the natural-gas reforming plant

In an existing pressure-gasification process with natural-gas enrichment it is, of course, most economical to mix methane, after hydrogen sulphide removal, directly into the grid gas without reforming.

Our reforming plant[2] was designed and built before we realized the possibility of crude-gas conversion. The task of our plant was then to reform natural gas so that, after removal of carbon dioxide, natural gas and nitrogen could be added; in other words, to use in town gas a proportion of our natural gas supply without reforming.

In future, this plant will be used only when the crude-gas conversion plant is working to capacity. The reforming plant is thus becoming a standby for emergencies.

REFERENCES

(1) "Die Erzeugung eines Stadtgases mit geringem Gehalt an Kohlenmonoxyd" von F. Jordi, Schweiz. Published at the 8th International Gas Conference in Stockholm 1961.

(2) Die Erzeugung von Stadtgas aus Erdgas in der Steinkohlengas A. G. Dorsten, von R. Pasternak. *Brenstoff-Chemie* No. 10, Vol. 41, pp. 294-297.

SOME IMPRESSIONS OF THE DOMESTIC USE OF GAS IN THE UNITED STATES AND CANADA

By F. J. EATON, Ph.D., B.Sc., M.I.Gas E.
Deputy Manager, Watson House

G. H. FUIDGE, B.Sc., M.I.Gas E., M.Inst.F.
Manager, Central Laboratories, South Eastern Gas Board

and

D. R. WILLS, B.Sc., A.C.G.I., M.I.Mech.E., M.I.Gas E., M.I.H.V.E., M.Inst.F.
Gas Council, Watson House

COMMUNICATION NO. 592

TABLE OF CONTENTS

		PAGE
I	Summary	671
II	Scope and Purpose of Visit	671
III	Conditions of Gas Supply	672
	(A) Problems of Supply	672
	(B) Pattern of Sales	673
IV	Testing and Approval of Appliances	674
	(A) American Gas Association Cleveland	674
	(B) Canadian Gas Association, Toronto	674
V	American Housing	675
VI	Space Heating	676
	(A) Present Position and Trends	676
	(B) Central Heating by Warm Air	676
	(C) Some Design Considerations	677
	(D) Central Heating by Hot Water ("Hydronics")	678
	(E) Independent Room Heaters	678
	(F) Research	678
VII	Air Conditioning	679
VIII	Incineration	680
	(A) Bulk Incineration	680
	(B) Independent Incinerators	680
IX	Chimneys and Flues	681
X	Control Devices	681
	(A) General Design	681
	(B) Flame-failure Devices	681
	(C) Ignition Systems	681
	(D) Thermostats and Magnetic Valves	682
	(E) Self-energizing Thermo-electric Devices	682
XI	Other Domestic Uses of Gas	683
	(A) Tumbler Dryers	683
	(B) Cooking	683
	(C) Water Heating	683
	(D) Lighting	683
	Acknowledgments	684
	Appendix.—Itinerary and List of Visits	684
	Presentation, Discussion and Reply	684

I SUMMARY

The paper gives in brief some of the information on the domestic use of gas gathered in a short tour of the East and Mid-West of the United States and the East of Canada. It is stated that the Authors concentrated mainly on the use of gas for space heating in all its aspects, installation, controls and servicing, but the opportunity was taken to examine recent developments in incineration and tumbler driers. Mention is made of visits to the American Gas Association, the Canadian Gas Association, American Government agencies, research centres, gas utilities and the manufacturers of appliances and other equipment.

The paper deals essentially with the possible applications of American experience to developments in Great Britain, but in the pleasant exchange of information that took place in the discussions it was found that much of the Authors' experience was of interest to their American friends.

II SCOPE AND PURPOSE OF VISIT

This visit was made as the result of a recommendation at the Gas Council Commercial Policy Committee when, in November, 1959, its members visited Watson House and discussed the Annual Report of the Watson House Centre, which dealt largely with technical developments in space heating.

Mr. D. R. Wills, Dr. F. J. Eaton, Mr. G. H. Fuidge, Mr. F. E. Hodgdon.
Mr. F. E. Hodgdon demonstrating a " powerpile " spark-ignition device to the Authors of this paper at the A.G.A. Laboratories, Cleveland.

It was known that the use of gas for space heating had been widely adopted in America. Clearly this must have involved dealing with many of the problems that were now exercising the Authors' minds in this country. Hence, the main purpose of the visit was to investigate the current practice in the United States and Canada. Arrangements were made to obtain a comprehensive picture of the present position by visiting the American Gas Association, (A.G.A.), the Canadian Gas Association (C.G.A.), gas utilities, appliance makers, trade associations and research organizations.

It was particularly pleasant to be able to visit the hospitable and ever helpful A.G.A., to renew the contacts made by Mr. L. W. Andrew in 1955, and to discuss appliance design and approval with Mr. F. E. Hodgdon (Director of the A.G.A. laboratories at Cleveland), Mr. Lee Robey and their staffs.

The opportunity was taken of following up two developments that have been under investigation at Watson House, namely, the use of gas for incineration and in tumbler driers and to obtain such other information on the domestic use of gas as was possible in the time available.

During the visit, the Authors had discussions with some 80 members of 35 different organizations listed in an appendix to this paper.

III CONDITIONS OF GAS SUPPLY

The subject of gas supply and distribution in America was described very fully in the British Productivity Team Report on Gas.* The present team visited The Institute of Gas Technology at Chicago, and two gas companies, the Brooklyn Gas Company and the Chicago Peoples' Gas Light and Coke Company. The information obtained was useful in providing the general background for the Authors' studies of the technical aspects of the domestic uses of gas.

(A) Problems of Supply

In all except a few small areas of the United States, the gas supply is natural gas of about 1,000 Btu/ft³ calorific value, consisting of over 90 per cent methane; it is non-toxic and in most cases almost sulphur-free. Supplies are plentiful, and the use of gas represents some 38 per cent of the total energy consumption in the United States, compared with 13·7 per cent for solid fuel and 33 per cent for oil. The price of gas is low, and the relative costs of the various fuels are well shown in Figure 1.† The largest use for gas is for space heating, and it has been estimated that in 1958 the house heating load had reached nearly 64 per cent saturation for the entire United States. The further development of the space heating load is mainly a matter of availability of gas and particularly of pipeline capacity.

The use of gas for space heating has, of course, created a serious problem of peak demand. Even in Chicago, where there is a supply for industry, the ratio of the maximum to the minimum day's demand is 6:1. Apart from "peak shaving", using liquid petroleum gas, the peak-load problem has been dealt with in various ways. In many areas, gas is available at a lower price "off peak" over a

* Gas: Report of a Productivity Team representing the British Gas Industry. (British Productivity Council; May, 1953.)

† The 1959 Annual Report of the Chicago Peoples' Gas Light and Coke Company.

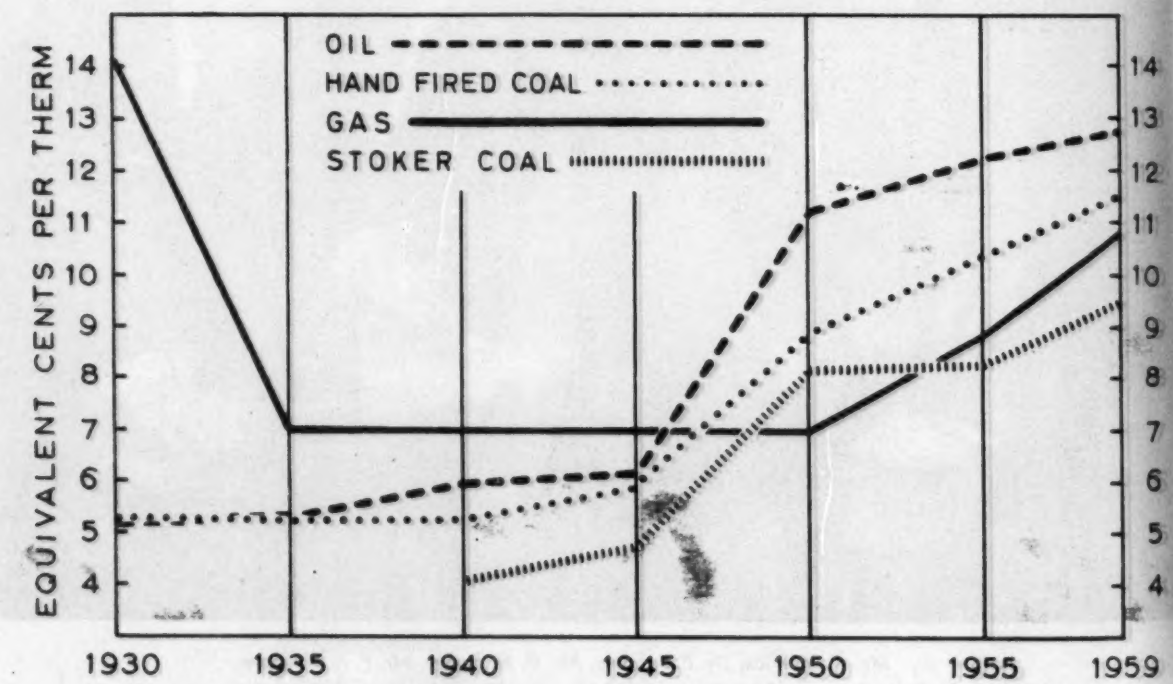


FIGURE 1.—*Relative Costs of Fuels in Chicago.*

period of six to eight months, and, in addition, gas is supplied on an "interruptable" basis at a very low price for industrial purposes and even for steam and electricity generation. The notice for interruption ranges from 30 min to 2 h, oil being used as the alternative fuel.

Seasonal storage is being developed to the greatest possible extent, and this is carried out in depleted natural gas and oil fields and, more recently, in "aquifers", which are structures of water-bearing porous sandstones in anticline form and sandwiched between impervious rocks. The storage field at Hersher, Illinois,* now contains some 40,000 mill. ft³, and withdrawal from storage is up to 30 per cent of the output on the maximum day. Consideration is also being given to the underground storage of liquid methane.

Although gas supplies are plentiful and are being increased every year, it is realized that they are not unlimited, and Dr. Elliott, the Director of The Institute of Gas Technology, has studied very carefully the relationship between the availability of supplies and the probable future demands for gas.† He has predicted that there will be a need for supplementary supplies in the 1970s and he is confident that a workable process for the production of additional gas by the complete gasification of coal will be available in time.

(B) Pattern of Sales

It is interesting to note that, in Chicago, domestic customers with space heating have an average consumption of some 1,700 therms, and customers without space heating some 350 therms. The total gas consumption for the Peoples Gas Light and Coke Company and associated companies (including "off-peak" and "interruptable") is 4,500 mill. therms, compared with 2,800 mill. therms for the whole of the British gas industry.

With regard to appliance sales, only a small proportion are sold by the gas companies direct, in Chicago, some 20 per cent; the remainder are supplied to consumers through dealers and contractors.

* This at the proposal stage was described and illustrated in the Productivity Report. (*Loc. cit.*)

† The Long-range Supply of Gas. Martin A. Elliott, Director, The Institute of Gas Technology.

FIGURE 2.—*Demonstration Panel on Air Heating in the Peoples Gas Light and Coke Company, Chicago.*

In Chicago, sales and service are sub-divided into domestic, commercial and industrial sales. On the domestic side, close liaison is maintained with architects and builders and, although there is no legal obligation, builders normally submit drawings of all new gas installations to the gas company for checking as to suitability, safety, *etc.*

An interesting feature of the gas showrooms at Chicago is that, in an area called the Clinic, full details are shown, for the benefit of architects and builders, of the installation of service pipes, meters, air ducts, *etc.*, and even in the sections for the general public exhibits include comprehensive drawings and examples of hot water and warm air installations. (Figure 2.)

Considerable attention has been given to the problem of servicing. Chicago employs three grades of service men who between them deal with all appliances and are capable of replacing parts of appliances. There is a school for the training of these men, and all new appliances are demonstrated there; there are frequent refresher courses. A 24-h service is maintained and, in the event of the failure of a control device on a heating installation, a service man will, if necessary, keep the plant going by manual operation until new parts are obtained.

A recommendation is made to consumers that all appliances should be cleaned at two- to five-year intervals, and this is carried out for a small charge. For a small charge also, space heating appliances can be lit up by the gas company at the commencement of the heating season.

IV TESTING AND APPROVAL OF APPLIANCES

(A) American Gas Association, Cleveland

In comparing the A.G.A. and British testing and approval procedures, it is important to realize that in America there are many more appliance makers serving a domestic market of about five times that of this country; furthermore, the makers' works are widely dispersed over the continent and about 80 per cent of sales are made through dealers. The A.G.A. is a trade association with membership comprising utilities, manufacturers, holding companies, service companies and private members, including, for example, a number in the British gas industry. The main Approval Standards Committee includes in its membership senior executives of the A.G.A., the utilities, the American Standards Association, the appliance makers and the C.G.A. as well as outside interested bodies such as the U.S. Bureau of Mines and the Federal Housing Administration. A number of sub-committees deal with the individual types of appliance.

The A.G.A. approval procedure differs in a number of respects from our system. A fee is charged for each test. All appliances must be "off tools"; laboratory prototypes are not accepted. A date for the commencement of the tests must be booked in advance; at the time of the visit, the waiting period was about eight weeks. All tests are on a "go/no-go" basis. Should the requirements not be met, makers representatives are given the opportunity of making modifications on the spot, for which purpose lock-up rooms and workshop facilities are provided.

To avoid the possibility of passing on confidential information from other makers, no advice is given officially by the A.G.A. on modifications, but considerable help is given by manufacturers of controls. Provided no modifications are necessary, the testing times are quite short, a few days only for most appliances. To achieve this, the 160 A.G.A. testing staff work in two shifts covering from 8 a.m. to midnight, five days a week.

The Authors do not consider that the American approval procedure is suitable for the conditions in this country, but certain aspects are being studied by the Watson House Centre.

Although the A.G.A. is fully recognized as the Appliance Approval Authority, about 11 of the larger utilities carry out check tests on the appliances they intend to sell. This testing may cover some of the A.G.A. requirements and in some cases additional ones that the particular utility considers to be necessary.

To ensure satisfactory standards of production, the A.G.A. has a staff of 20 inspectors who annually pay one announced visit to makers' works, and one or two unannounced visits. The makers welcome these inspections as a valuable addition to their own inspection procedure. The Watson House Centre makes many visits to makers' works, but such visits are generally to discuss problems and defects and not primarily to make official routine inspections. In America, a further check on appliance performance and reliability is provided by the collation and statistical analysis of appliance defects at the Cleveland laboratories. Information is obtained from the utilities, agents and manufacturers, and the data are used as an indication of where modifications or a special investigation might be required. In this country, some Gas Boards now operate a defects scheme, but a national scheme would be more comprehensive and also help in providing data for research and development programmes.

The A.G.A. requires that all appliances that have not been modified and are still in production five years after approval shall be re-submitted for test. This ensures that all appliances are kept in step with current standards, and it is a requirement that, with possibly some modification to the time period, the Authors consider might usefully be adopted in this country.

Research in the A.G.A. laboratories was concerned mainly with appliances. At the time of the Authors' visit, they specially noted the work on pilots of low gas rate and developments on cookers. There was also an experimental spark ignition device using a "powerpile", which is described more fully in Section VIII. The photograph of the Authors with Mr. F. E. Hodgdon shows Mr. Hodgdon demonstrating this device in the Conference Room at the A.G.A. laboratories.

The A.G.A. laboratories are concerned mainly with appliance testing, approval, inspection and the tabulation of defects so that steps can be taken quickly to overcome faulty designs. Research and development at present represent a relatively small section. Design, maintenance and servicing manuals are the responsibility of individual manufacturers, or, for example, in the space heating field, of such organizations as the National Warm Air Heating and Air Conditioning Association and the Institute of Boiler and Radiator Manufacturers

(B) Canadian Gas Association, Toronto

The Organization of the C.G.A. is very similar to that of the A.G.A., and a C.G.A. representative is a member of the A.G.A. Appliance Committee. Testing, which is mainly based on A.G.A. standards, is carried out at two laboratories, those of the Ontario Research Foundation in Toronto, which was visited, and of the British Columbia Research Council in Vancouver. Fees are charged for all tests.

For tested appliances and accessories, the C.G.A. used three symbols:

(1) *Approval symbol* affixed to approved appliances

complying with national published requirements for safety, construction and performance.

(2) *Listing symbol* for accessories meeting the necessary requirements.

(3) *Tested symbol* for appliances or accessories that have been tested, but for which no agreed standards are at present available.

V AMERICAN HOUSING

Two days were spent with the Federal Housing Authority, Washington, discussing with various departments current practice in domestic heat services in relation to house design. The Authors visited also a number of private houses and two research residences. From all of these sources, a broad picture of American housing was obtained.

By far the greatest proportion of new building is private, and, of 1·2 mill. new dwellings built annually only 35,000 are built by public authorities. Some 80 to 90 per cent of new housing is of single-family dwellings on vacant property. Tall blocks of flats are uncommon, but where they are built it is the usual practice for the rent to include all the utilities, which are not separately charged or even metered. Supplies to the flats usually have a meter loop that enables the manager to check consumption and, if justified, make a surcharge.

The popular type of house with the high-income groups is the "ranch" house, which is, in fact, a very large bungalow invariably with a two-car garage. It is normal for the American house to have a roomy and fairly lofty basement, which not only houses the heating and hot water installations, but also provides a children's playroom and/or husband's workshop. Another type of house that at present is very popular is the "split-level" house. In this, one half of the house is at ground level over the basement, and the other half is half a storey higher over a partially sunk garage. This makes an attractive internal layout and is less expensive per unit of floor area than the ranch house. It presents some problems in heating which are discussed in Section VI. Figure 3 illustrates the split-level research residence of the University of Illinois, Urbana. An inexpensive form of construction is the "slab" house, which, as its name implies, is a single-storey house on a concrete floor, with no basement. In modern houses, open and semi-open plans are usual and kitchens are elaborate with built-in cookers as the present fashion.

The Federal Housing Authority operates under the National Housing Act, 1949, which states the objectives as: "to encourage improvement in housing standards and conditions, to provide a system of mutual mortgage insurance and for other purposes". None of the various agencies under the F.H.A. Act actually build, but, since most banks and insurance companies require a guarantee before granting a mortgage, the very comprehensive F.H.A. standards become in effect national standards for nearly all house property. Although there are no national building codes and each State issues its own code, in practice these are based on the F.H.A. minimum standards.

For space heating, the F.H.A. standards require that the calculated heat loss of the living unit shall not exceed 50 Btu/ft² of floor area, all spaces to be heated to a temperature of 70°F. For heating by electricity, the maximum heat loss figure is 30 Btu/ft² h because of the higher cost of electricity.

For comparison, in Britain the heat loss for post-1950 houses is about 35 Btu/ft² of floor area for a temperature rise of 35°F, against the American design temperature rise of 85°F. No standards are laid down for ventilation, which is generally kept to a minimum to reduce heat losses. Mechanical extracts from many bathrooms and kitchens is provided in apartment houses.

FIGURE 3.—*Air Conditioning Research Residence No. 4 Built by the National Warm Air Heating and Air Conditioning Association, for Research Work at the University of Illinois.*

Communal laundries are a feature of apartment blocks, which are nearly always provided with washing-machines and tumbler dryers. Drying cabinets such as are used in England are unknown. Tenants pay on a coin-in-the-slot principle for the use of the machines.

The American Housing and Finance Agency has a Research Division that issues many useful technical manuals on problems of house design, construction and maintenance. Information on refuse disposal and incineration is included in other sections of this paper.

VI SPACE HEATING

(A) Present Position and Trends

It is quite impossible to generalize about space heating in America, which is a vast continent with a wide range of climatic conditions and traditions, and it is necessary clearly to distinguish between the northern and southern states. Thus, central heating is found mainly north of the Mason-Dixon Line, whilst in the south the traditional independent room heating still continues. Even in northern cities such as Chicago, about 50 per cent of gas space heating is still in the form of independent room heaters, chiefly of the convection type. Such heaters are mainly replacements for oil-burning and solid-fuel stoves.

The central heating systems are divided approximately into 65 per cent by warm air methods and 35 per cent by hot water (now known as " hydronics ") and the preference for warm air heating is attributed mainly to the lower capital and installation costs, about half that of the hot water system, and also to the convenience of installation in the basement type of dwelling.

A further factor is the expansion of air conditioning in the summer, regarded as essential in offices, but now extending even to homes and for which air is a convenient medium.

We were somewhat surprised to learn of space heating by direct electrical methods, which is extending mainly in the south-central and southern states. There are now about 900,000 all-electric houses in use, mostly in new buildings. After some resistance from housing authorities, all-electric houses are permitted in the Federal Housing Building Regulations, provided the house insulation gives about half the heat loss specified for dwellings heated by gas or oil. The interest in electrical heating is proceeding although the cost of electricity is 2·5 to 3·5 times that of gas. This electrical heating has an appeal to the American's liking for change, and publicity emphasizes flexibility and controllability, both permitting variability in the environment.

A major problem in Great Britain to-day is the heating of tall buildings, particularly flats. In America, the automatic choice today is central heating of the hot water-radiator type, with gas-fired boilers often installed on the roof. Induced-draught fans are commonly used in the larger installations. Air conditioning is extending in the more expensive apartment blocks and would be of a central type supplying the cooling medium to unit conditioners under the independent control of the user.

Much interest was shown in the individual heating systems and in the Se-Duct and branched flues now used for flats in this country, for the Americans also have plenty of evidence of waste and extravagant usage even with their higher standards.

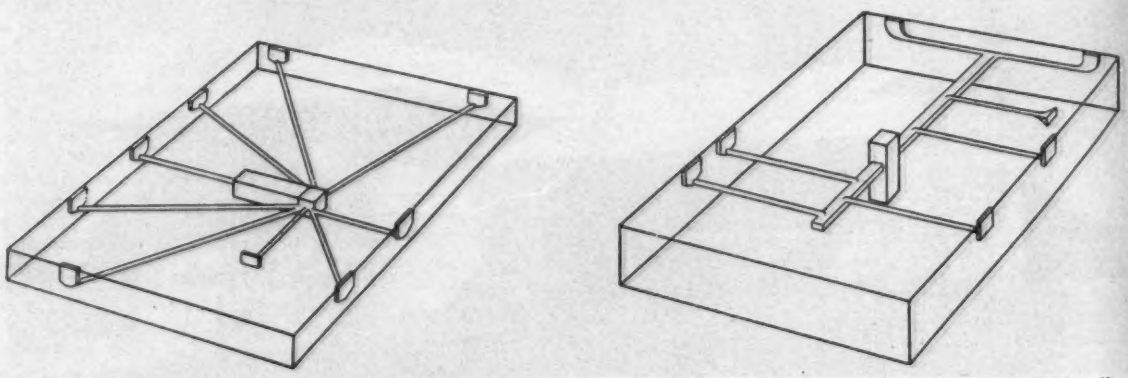
Although the cost of heat services is usually included in the rent, there appeared to be a desire on the part of many of the authorities that everyone should pay for what they actually use, but so far there is no convenient and cheap method of heat metering.

(B) Central Heating by Warm Air

The principal organization dealing with warm air heating is the National Association of Warm Air Heating and Air Conditioning, U.S.A., and its main objective is to provide performance and installation design data. It sets up recommended practice similar to the British codes of practice, and also sponsors research projects carried out at the University of Illinois and elsewhere.

Both in the U.S.A. and Canada, there is a shortage of competent engineers available to deal with design and installation problems, and the installer relies on simple design charts and tables. He uses standard fitments and ducts provided with balancing dampers. This balancing is practicable because of the adequate fan capacity of American heaters. It was admitted that this procedure is not precise, but is helped by the similarity of house design and the availability of package units. If complaints arose, these were rectified by more experienced and skilled installation engineers.

In Great Britain, because of the increasing interest in warm air heating, we face a similar problem of shortage of



(*a*) " Spider " Principle with Cabinet Heater in Crawl Space. (*b*) " Plenum " System in Basement with " Hi-boy ".

FIGURE 4.—*Duct Arrangements for " Perimeter " Heating.*

skilled designers. With selective warm air systems, however, skilled design is seldom necessary, but, if the development leads to the wider application of whole-house warming systems, attention to more detailed design will be necessary.

(c) Some Design Considerations

Design temperatures are much higher than in Great Britain, being usually 72° to 75°F. Winter temperatures in the Middle West may be as low as −30° to −40°F, and −10°F is taken for design purposes, a differential of 85°F. This accounts largely for the low level of ventilation in American houses, and for the fact that in many parts of America there is a call for humidifying devices added to the air-heating system.

In the modern homes and research residences visited, the air was distributed by the "perimeter" system in which the delivery is at low level near the outside walls. It was claimed that this provides the most comfortable conditions with the lowest vertical and horizontal gradients, although it was stated that the running cost was higher than with delivery from the inner walls.

Selective warm air heating methods as now employed in Great Britain provide the lower running cost, but, if warm air heating continues to develop at its present rate, then there is little doubt that the need for better comfort conditions will follow, and, therefore, particularly in whole-house warming systems, perimeter methods will be of importance.

Separate returns from the bedroom or other rooms are not normally employed, and it was stated that a single or perhaps two central returns were all that were necessary. Sheet-metal ducts are the universal practice; ducts of plastic material, because of fire risks, are not permitted for domestic application, but can be used in some industrial and commercial air heating systems.

There are various forms of duct system. In the "spider" system, the perimeter grilles are fed by radial ducts from a short central duct. This is shown in Figure 4*a*. An extended plenum system shown in Figure 4*b*, uses a large central duct from which correctly sized branches lead to the perimeter outlets. Special attention is paid to the design of grilles, and a large number of types are available. One form is a perimeter baseboard diffuser about 24 to 30 in long and 10 in high, from which the air is delivered in a slightly upward direction at a velocity of about 300 ft/min for heating and about 400 ft/min for cooling.

The rating of the warm air heating systems is generally from 60,000 to 90,000 Btu/h output and the fan power sufficient to circulate 1,200 to 1,400 ft³/min of air against a total head of 0·2 in w.g. at the heater delivery. In Great Britain, it is doubtful, even with whole-house warming units, whether the total volume of air delivered is more than 450 to 550 ft³/min.

In nearly all the examples seen, the noise level was extremely low and one practice is to employ an oversize blower running at a low speed. One maker uses the term "whisper quiet".

The controls of the heating systems were always adequate, including sensitive room thermostats of the anticipatory type, clock controls and, in practically every case, fan over-run controls to ensure that the fan continued running for a period after burner shut-down to remove the residual heat from the heat exchanger.

Mention was made of the often-quoted "cold seventies" associated with warm air heating, and suggested by the advocates of "hydronics" to be due to the low thermal capacity of the warm air system and the consequent increase in thermal gradient when the fan shuts down. It is claimed, however, that this has been largely overcome by the perimeter system and the continued circulation of the air at a lower rate during burner shut-down.

There are four general types of air heaters, "Hi-boy" (see Figure 5) with top air delivery for basements. "Lo-boy" with top outlet but a fan at the side to reduce height. "Counterflow" with bottom outlet where the heater is on

FIGURE 5.—"*Hi-boy*" *Air Heater.*
(By courtesy of Lennox Industries, Incorporated.)

the same level as the living area. "Horizontal Cabinet Types" are for installation in crawl spaces, attics, etc.

Because of the general air-tightness of American houses, combustion air was often fed from outside by a separate 4 in. duct. The heating system always depended on 100 per cent recirculation.

(D) Central Heating by Hot Water ("Hydronics")

The interests of the manufacturers of boilers, radiators and "hydronic" systems generally are co-ordinated in the Institute of Boiler and Radiator Manufacturers (I.B.R.M.), which acts for its members in the same way as the National Association of Warm Air Heating and Air Conditioning.

It was stated that the main interest in hot water methods of central heating is directed towards perimeter baseboard systems and that the conventional radiator is fairly rapidly being superseded. The claim made for baseboard heating is that some 15 per cent less heating surface is required compared with conventional radiators. Work at the research residence at the University of Illinois has demonstrated that the temperature and comfort distribution is better, and this may perhaps justify a smaller amount of heating surface.

In control of hydronic systems, modulation with outside temperatures is favoured. The pump runs continuously and temperature modulation is either by a mixing valve or control of the heat input to the furnace. Boiler controls are conventional.

Contrary to practice in Great Britain, the domestic "hydronic" systems employed the "closed" principle with a hot water circulator temperature of about 215°F, which permits the use of smaller radiator surfaces.

An interesting form of heating by "hydronics" method is the subject of research at the J. B. Pierce Foundation and the University of Illinois. This is the "valance' system and is essentially a finned tube heater fixed at just below ceiling level. The claims made for this system were that, in heating, a blanket of warm air was floated across the ceiling providing an overhead radiating surface. During the summer chilled water is circulated through the heat transfer units, which results in a cold stream of air circulating down the outer walls. The temperature gradient is claimed to be very small indeed. A disadvantage of the system for heating is that at least one-third more heating surface is required.

(E) Independent Room Heaters

As mentioned earlier, independent room heaters are traditional in the south; in the north of the States and in Canada, gas heaters are sold to replace oil and solid fuel stoves.

(i) *Convectors.*—These comprise the greater proportion of all heaters sold. Some include an integral fan to improve the warm air distribution. Most are designed for conventional flueing.

(ii) *Convector-Radiant Heaters.*—Some of the heaters have high-temperature radiants with glass fronts, similar in principle to the "sealed" fires being developed in Britain. A heater under test is shown in Figure 6. The radiant output was not impressive, and the radiants were of crude design.

(iii) *Balanced-flue Heaters.*—The merits of balanced-flue heaters are still under discussion, although the gas utilities are interested and the A.G.A. is investigating design and performance standards. In this matter, there has already been an exchange of experience between the Authors and the A.G.A.

American room heaters are much bulkier than in this country, with the emphasis on convection. Not one was suitable in its existing form and rating for ready application in Great Britain, but there were a number of interesting features of design, and several types are now under examination at Watson House. All heaters seen were fully equipped with flame-safety devices and most had an integral room thermostat or facilities for fitting one.

(iv) *Overhead Radiant Heaters.*—The introduction of the Schwank-type heaters in the U.S.A. has directed a great deal of attention to the use of radiant heaters for both space heating and industrial application. So far, the use is in well-ventilated situations and some attention has been given to outside use. There has been some prejudice against the use of overhead radiant heaters in the U.S.A., but where they have replaced or partially replaced convection heating in industrial workshops, it is claimed that the fuel economy has been substantial.

(F) Research

It seemed that nearly all research in heating and ventilating, environmental comfort and related subjects was carried out by such organizations as the J. B. Pierce Foundation, the American Society of Heating and Ventilating Engineers, and by research sponsored at Universities by such organizations as the National Association of Warm Air Heating and Conditioning and the Institute of Boiler and Radiator Manufacturers.

(i) *Comfort and Environmental Research.*—This was in hand at the J. B. Pierce Foundation, the A.S.H.V.E. Laboratories, Cleveland, and the University of Illinois, although the last was concerned with abnormal working conditions rather than comfort in the home.

At the A.S.H.V.E. laboratories, the present programme includes the study of subjects doing light work in a temperature-controlled room with different combinations of radiant warmth and air temperatures. The effect of the introduction of ionized air was part of this study. Some

FIGURE 6.—*Radiant-Convector Heater in A.G.A. Laboratories, Cleveland.*

of this work resembled that of Dr. Bedford in this country, and some of the results are in accord. It had been concluded that:

(*a*) The relative humidity had little effect on normal comfort levels and changes from 30 per cent to 70 per cent produced little or no difference in subjective response except at extreme temperatures outside the normal comfort zone.

(*b*) The effective temperature index used in America was now under some criticism because it had been based on short period effects.

(*c*) The effect of short-period changes in thermal environment is being given some thought because some authorities feel that the thermal environment in the American home may lack variety and stimulation.

Odour level is being studied because it can have a significant effect in the American home, with its low ventilation rate.

It would seem that, as standards of heating and air conditioning are raised, the subjects become more sensitive to small changes, and much more is expected from controls than, maybe, is the case in this country. A detailed study of controls and control systems was in progress, with particular attention to response and sensitiveness.

(ii) *Research Residences.*—Sponsored research for the National Warm Air Association and the Institute of Boiler and Radiator Manufacturers was being conducted in two research houses of the "split-level" type at the University of Illinois. (See Figure 3.) This type of research is considered as important, and the examples seen had followed on from several research residences of different types.

In the warm air residence, full air conditioning was being studied, the system being of the perimeter type. Apparently, "split-level" houses present special problems in the distribution of the warm air and its effect on temperature gradient. The standard of insulation was also important. The house was admirably instrumented and the recording and analysis would need the attention of several expert workers. The director of the research agreed that it was important to supplement any pre-occupation studies by fully instrumented tests during normal occupation.

At the I.B.R. residence, which was also of the split-level type, detailed comparisons of a baseboard radiator system and the "vallance" system were in progress. Heating and cooling were receiving attention. Pump circulation for "hydronic" systems was always preferred, and attention was being given to control systems.

(iii) *Appliance Research, Development and Testing.*—The research at the A.G.A. Laboratories included a fundamental study of heat transfer elements in air heaters, with the objectives of improving performance, reducing size and generally cheapening production.

Appliance Testing.—Air heaters are tested in a large laboratory equipped similarly to the large Appliance Laboratory at Watson House. Testing was mainly concerned with burner performance, flue clearance, surface temperatures, including tests where installed in a recess. (See Figure 7.) Much attention is given to ignition devices, control devices, *etc.*

In the tests on air delivery, temperature and appliance efficiency, tests are made over a range of air temperature rise from 60° to 115°F. Air flow measurements are not made, and delivery characteristics are left to the appliance makers' tests; at one maker's works visited, the tests are clearly very adequate.

FIGURE 7.—*Air Heater being Tested in a Recess, at A.G.A. Laboratories, Cleveland.*

Life tests are made and some control systems undergo 100,000 cycles or more. For air heaters, special attention is given to "torture" testing, where the air heater undergoes conditions of rapidly changing heating and cooling at 25 per cent overload.

There were no great differences between English and American practice in the testing of independent room heaters. Tests under vitiated air conditions were applied to both vented and unvented heaters because the tightness of construction of American houses was such that leakage from draught diverters had occurred.

For efficiency tests, flue gas loss methods were always used, and the heat output found by difference.

VII AIR CONDITIONING

Air conditioning has always been widely practiced in the United States and the present rate of growth of this industry is greater now than at any previous time. Space does not permit a full treatment of this subject, and it is possible to mention only a few features.

Two basic refrigeration systems are available for application to air conditioning; those of absorption and vapour compression. Thermodynamically, vapour compression cycles are much more efficient, the coefficient of performance being six to seven times greater than for the absorption plant on which the application of gas mainly depends. In spite of the rapid expansion of air conditioning in the U.S.A., the gas industry is getting only about 5 per cent of the current central residential market.

The need for air conditioning has been brought into prominence by the newer techniques of building, with their greater degree of exposure, greater expanse of glass and the

appreciable amounts of adventitious heat gains in a climate where summer temperatures in excess of 90° can occur. New commercial buildings will generally have large central units with electrically-driven vapour-compression machines and the cooling medium circulated to individual units on the different floors.

Although, in the larger plants, the vapour-compression types predominate, there are a number of large absorption-type plants available; these may show to advantage where the load factor is small and the use of the plant more intermittent. In such plants, the heat is supplied in the form of hot water or steam from gas-fired boilers.

A type of air conditioner of particular interest to the gas industry is one that integrally includes the gas-fired steam boiler for providing the heat necessary with the absorption cycle, but at present there are only two sizes, namely 3½ and 5 ton units.

There is no small-unit air conditioner operated by gas, and successful development is extremely unlikely.

Comparison between gas- and electrically-driven vapour-compression air conditioning plants show that the capital costs for the gas-driven plants are higher, service costs are higher and noise problems are greater. Gas must be sold at a very low rate to compete with electricity in running cost, and, although this is possible in the U.S.A., competition is extremely keen.

It is significant that the electricity industry has summer peak problems because of the rapid growth of electrically-driven air conditioning; it is because of the high summer load that the electricity industry is giving so much attention to the use of electricity for heating. It is not so concerned with "off-peak" heating as is the electricity industry in Great Britain.

A number of air conditioners working on the heat-pump principle were seen, but it was stated that these are not a good proposition unless the demand for heating and cooling is roughly balanced.

Summarizing: it would seem that, even in the U.S.A., where gas enjoys a very strong price advantage, gas air conditioning is only getting a small share in the market. In Great Britain, gas has a very poor price comparison and for larger units for commercial application can hardly compete except in special cases such as use in small public halls, restaurants, and so on. It is of interest to know that one or two firms of American origin are exploring the possibility of a market in this country for gas air conditioning units of 3½ and 5 tons capacity with integral boiler and gas burner.

VIII INCINERATION

The destruction of different types of refuse has roused interest in this country and has been given attention at Watson House. Reports on the installation and use of small gas-fired incinerators have also appeared, and the introduction of an American-type smokeless incinerator has proved successful for a number of applications in this country.

In the U.S.A., gas-fired incineration has been much more extensively applied, both in the form of individual domestic incinerators and for bulk incineration by flue- or duct-fed incinerators in blocks of apartments and office buildings.

The individual incinerators have received special study and an A.G.A. Standard now exists for approval of this class of appliance.

Housing authorities favour *in situ* destruction so long as it is completely smokeless; all the city authorities are particularly concerned with atmospheric pollution.

(A) Bulk Incineration

In general, bulk destruction is the preferred method. Some form of duct-fed incinerator is considered in planning new buildings. The trend towards packaged rather than tinned goods might well mean even more active attention to destruction by incineration.

At the present time, in New York alone, there are some 11,000 flue-fed incinerators, which are estimated to burn 600,000 tons of refuse annually. Incinerators to dispose of garbage and other waste matter are required by law in New York City for multiple dwellings of four or more storeys occupied by more than 12 families and erected after 1st October, 1951.

To reduce air pollution, some cities have adopted restriction against new installations, but this was considered to result from experience before gas after-burners were employed. A number of devices have been tried for reducing pollution by adding to existing incineration plants gas overfire and after-burners in combination with a scrubber device to deal with fly ash. Annual costs of operation are between $2·18 and $2·25/room, or about £3 5*s.*/room for each flat. The gas utilities have installed a large number of after-burners on existing flue-fed incinerator plants of ratings up to 500,000 Btu/h, and both in the U.S.A. and Canada the view was expressed that all flue-fed incinerators would in time be fitted with gas after-burners.

With a flue-fed incinerator, the refuse is charged by the tenants through service doors at each floor level. The material accumulates in the furnace, and in older installations is ignited by the janitor. The products of combustion pass up the same flue and are discharged at a suitable height above roof level. In most cases, special arrangements are made to lock the service doors during burning periods.

In newer plants that were visited in New York, primary and after-burners were employed under fully automatic control of firing periods. One downfeed chute for the rubbish, and a separate flue, is now used under induced draught arranged so that the refuse chute is always under a negative pressure when firing, during which period an automatic damper closes the main feed chute. The burners are fully protected and a special control prevents runaway combustion.

The plant seen, serving 50 flats in a seven-storey block, an early example of its kind, had been in successful operation for 18 months. The refuse was fully destroyed; bottles cracked, but did not slag; tins were fully sterilized. The reduction in bulk was down to about 25 per cent of the original quantity. The removal of ash and residue was by hand; there was no successful method, yet, of mechanical handling, and in any case it was not thought necessary. As this was an experimental plant, the costs were said to be higher than is now possible; even so, with gas at about 11*d.*/therm, the cost per flat per week, even with plant and power cost included, should not exceed 3*s.* 6*d.*

(B) Independent Incinerators

The sales of the small independent smokeless incinerator had not been as encouraging as was originally anticipated, but there were signs of more interest, and improvement in the position was anticipated. They are considered for houses, but seldom for flats, either singly or communally.

The reasons for a recession after the earlier success were explained to be that, before 1957, gas-fired incinerators were sold in large numbers without after-burners, and so much atmospheric pollution was produced that city authorities issued regulations against their use. Because of this experience, there was a cautious approach to the present smokeless incinerator and it has taken some time to establish confidence. Although in some parts of the U.S.A. there is no municipal collection of refuse, most localities have adequate collection facilities, sometimes twice per week. This is paid for in taxes and the housewife is not enthusiastic about adding a further chore and paying independently for it. In Canada, the incinerator was still regarded somewhat as a gimmick, and municipal arrangements are regarded as adequate. Bulk incineration, however, in commercial buildings and apartment blocks was increasing.

In spite of the slow present development of the market, where the independent incinerators had been sold, complete satisfaction had resulted and the A.G.A. was confident that the market would expand.

IX CHIMNEYS AND FLUES

In view of some difficulties being experienced in this country with the flueing of central heating boilers, it was interesting to learn that it is a requirement in the Minimum Property Standards issued by the Federal Housing Administration that all masonry chimneys shall be provided with fire-clay flue linings, with the exception of chimneys for fireplaces, which, of course, in America are used only very occasionally. The Minimum Property Standards also give detailed descriptions of the methods and materials of construction of the chimneys and linings. Requirements are also given for flues for gas appliances, which in America are known as "vents". These refer to type-B and type-BW gas vents. These must be "U.L.-listed", that is, tested and approved by the "Underwriters' Laboratories", test laboratories maintained by the insurance companies. The type-B vent is generally a round double-walled metal pipe, often with the inner pipe of aluminium and the outer of galvanized iron. The type-BW vent is oval for installation in partition walls.

One make of American "type-B vent" is now being offered in Britain, and, through the Watson House Centre, samples are being taken for trial by the Area Gas Boards.

The F.H.A. Standards state that the area of a flue shall be as recommended by the appliance manufacturer. The use of common flues is recognized by the requirement that, when two or more appliances are connected, the flue area shall be not less than the area of the largest flue connector plus 50 per cent of the area of all the other appliance connectors. This is probably a very satisfactory rule of thumb for the types of flue system usually met in America, but would rule out many "Shunt flue" systems used in tall buildings in Britain.

The position of termination is covered by the requirements that the terminal shall be at least 4 ft above the highest draught diverter, and shall be at least 2 ft above the roof ridge or any wall within 10 ft of the vent.

The correct sizing and other design features of gas vent pipes have been the subject of detailed investigation by the American Gas Association.* Based on this work, two research reports (No. 1,300 and 1,319) have been issued, which give comprehensive design procedures for individual and multiple (i.e., "common") vent systems including systems for multi-storey buildings. The design data are all directed at the complete evacuation of the products of combustion. Condensation in flues does not appear to be a major problem; this is not unexpected in view of the general use of double-walled flues and the high temperatures maintained throughout American houses.

As mentioned in Section VI of the paper, balanced-flue appliances, known in America as "sealed-combustion chamber" type, are still not universally accepted and the Authors' A.G.A. colleagues have been interested to have details of British experience and test methods. They were also interested in the Se-Duct, but naturally the development of this system requires the availability of a range of sealed-combustion chamber appliances, which is not yet the position in America.

X CONTROL DEVICES

It was known that there was a wide range of control devices for gas appliances available in America, and, accordingly, arrangements were made to gain as much information on controls as possible. The A.G.A. was very helpful in arranging a conference in the laboratories with represenatives of all the control manufacturers, and brief visits were made to the works of Baso and of Honeywell, Minneapolis. These confirmed that the American controls covered a much wider range than British devices and incorporated many new principles and ideas.

(A) General Design

The good external appearance and high standard of finish of American controls was noteworthy, and compactness was achieved by composite assemblies of a number of individual controls connected by gasket-sealed joints. (Figure 8.) In some of these, a number of different components can be fitted as alternatives in the same position. The assembly is usually arranged so that the working components can be removed for servicing and, if necessary, replaced by a service unit without interfering with the gas connexions. The control manufacturers arrange special training courses for service engineers and supply them with data sheets, service manuals, *etc.*

The Authors were told that, in general, the control systems are very reliable. Failure is usually due to some fault in the pilot. When electrical energy is used (e.g., in magnetic valves, room thermostats, *etc.*), this is always of low voltage, usually 24 V. This is in contrast to the general British practice of using line voltage.

(B) Flame-failure Devices

Thermo-electric devices have completely replaced bi-metal. The Americans have found bi-metal devices unreliable and assert that no-one has managed to design one that will fail to safe.

The A.G.A. does not normally require 100 per cent shut-off on flame failure (i.e., the pilot to be cut off), but many individual gas utilities, including Chicago, insist on this arrangement; accordingly, many appliances incorporate it as standard.

(C) Ignition Systems

(i) *Pilot Flames.*—There is a very large range of types of pilot head; many are similar to those in Britain, but there are a number of novel designs. It is a requirement that the

* Research in Fundamentals of Gas Vent System Design. Perry, E. H. *A.G.A. Res. Rept.* 1298A.

same flame must be used both to heat the thermocouple and to ignite the burner. Aerated flames are preferred, but special steps are taken to minimize the clogging of the air ports by lint. The so-called "Target" burner has no air ports; the flame is in a state of lift, stabilized by impingement on the target hood. (Figure 9.) Pilot gas rates are quite low, ranging from 500 to 800 Btu/h, and, for the standing pilots on cookers, the gas rate may be as low as 50 Btu/h.

(ii) *Electrical.*—Glow-coil ignition is common, using a stout nickel or platinum wire on 2½ V. Spark ignition is under development; it is said to be cheaper, but so far it has not been used commercially to any extent.

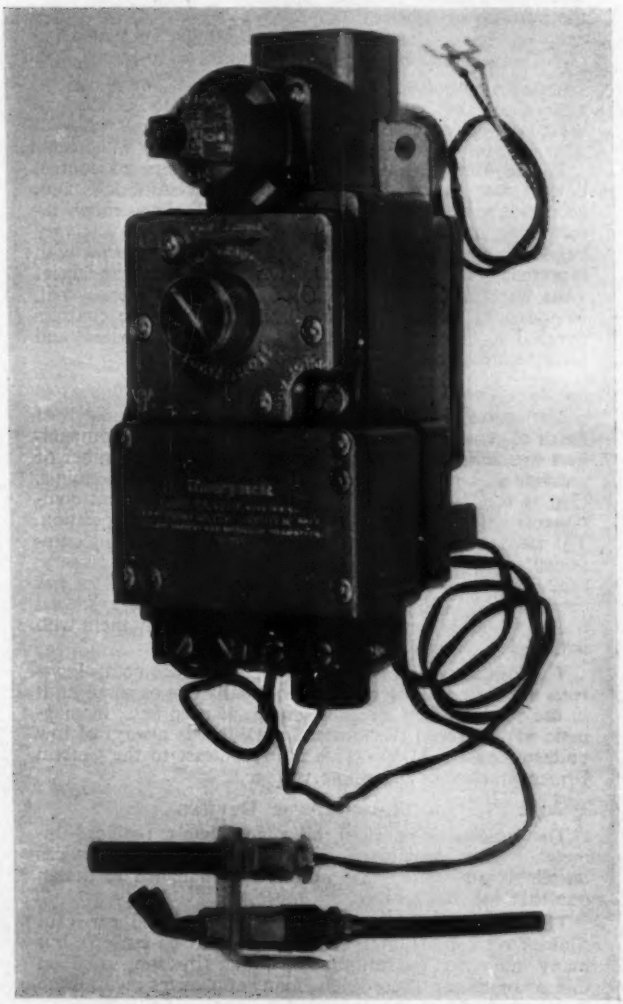


FIGURE 8.—*The Honeywell Junior Manifold Control, comprising three-position gas cock, flame-failure device using "Target" pilot burner governor and thermostat controller valve.*

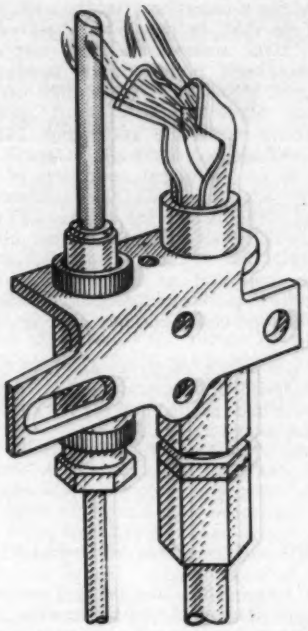


FIGURE 9.—*"Target" Pilot Burner and Thermocouple Assembly.*

(D) THERMOSTATS AND MAGNETIC VALVES

Considerable care is taken to ensure reliability of thermostats, and a number that the Authors saw were precision-made instruments. As a result, they usually respond to about 1°F. A number of manufacturers produce magnetic valves that are oil-filled and, therefore, silent.

(E) SELF-ENERGIZING THERMO-ELECTRIC DEVICES

These devices incorporate some form of thermocouple that produces a considerably greater amount of energy than the normal type. This is sufficient not only to hold open a magnetic valve, but also to open it; thus, no reset-button is required, nor any external supply of electricity. There are two types of self-energizing device. The powerpile consists of a thermopile of 20 or more couples in series so that an e.m.f. of about 750 mV is produced compared with the normal 30 or so. The thermopile is either in the form of a flat plate or wrapped around in the form of a cylinder. The other type uses as the active material a semi-conductor, usually lead telluride doped with bismuth. This gives a voltage of 250 to 300 mV. A further advantage claimed for these systems was speed of response, and operation times of only a few seconds had already been achieved during development. A considerable amount of work is going on in America on the subject of thermo-electricity, although the main incentive is a military one.

A further development of the application of these devices to gas appliances under consideration is the supply of sufficient power to operate the fan in an air heater so that the appliance can be completely independent of external electricity. There was a wide difference of opinion among authorities as to whether this development is practicable or even necessary.

As mentioned in Section IV, the A.G.A. is working on the application of a powerpile for the ignition of appliances. Current from the powerpile, heated by the appliance burner, charges a small nickel-cadmium battery that provides the energy for a spark for ignition when required.

XI OTHER DOMESTIC USES OF GAS

(A) Tumbler Dryers

The British Productivity Team reported the popularity of gas-heated tumbler dryers in the U.S.A., and this is still the position today. The tumbler dryer is regarded almost as a necessity in the American home and many types are now available, including one that is a self-contained automatic wash/medium-speed spin dryer/tumbler dryer.

All the types seen were equipped with fully automatic ignition, safety and time controls, the ignition being generally by glow coil working in conjunction with the safety device on a timed cycle. Any failure to ignite the pilot safely is followed by a complete shut down and recycle. Complete confidence in the control system was expressed.

The drying performance of American tumbler dryers is very good and they are more generous in size than domestic tumbler dryers in use in this country, mainly electric, which is an advantage for drying quality and presents few problems of accommodation in the more spacious American home.

In comparison with electric tumbler dryers, the gas-heated types have, by far, the greater share of the market in spite of a cost differential of $25 to $40 in favour of electricity, due to the fact that the association of gas and electricity means the additional controls and a burner system. In blocks of apartments, tumbler dryers fitted with a coin mechanism are often installed in drying rooms for communal use by tenants; this has proved popular both in the U.S.A. and Canada.

Several Canadian and American firms are interested in introducing their dryers to this country and there are a number already in use, successfully, in launderettes. In this application, the gas-heated tumbler dryer is proving very popular and the numbers in use have increased considerably in Great Britain in the last few years.

Although the gas-heated tumbler dryer may not find such ready application in the average English home as in the more spacious American one, there are real possibilities in communal drying rooms in flats, in hostels and the larger homes.

(B) Cooking

The first point of interest in connexion with cooking is the extent to which business has been lost to electricity. Mr. Kline, the President of Caloric, was emphatic that the reason for this was that the gas industry had lagged behind the electrical industry in modernizing gas ranges, both in appearance and in the application of automatic controls. He maintained that as far as Caloric was concerned, this ground had been completely regained and that in every respect his appliances were equal to or better than their electrical counterparts.

Built-in cookers have become very popular and it was clear from tests in progress at the various laboratories that special care has to be taken to ensure that the temperatures of the wooden cupboards surrounding a built-in oven are at a satisfactory low level.

It was noted that the American cookers are fitted with very simple types of pan support on flat, smooth hotplates. This gives a very clean appearance to the cooker, but, of course, the arrangement would not meet B.S.1250, which requires that the combustion is satisfactory with a re-entrant-based vessel. It is considered in America that the possibility of such things as buckets being used on a gas cooker is so remote as not to constitute a potential source of danger. Most cooker hotplates have at least one burner with a thermostatic head, but what was perhaps more interesting was that nearly all cookers have one hotplate burner of the duplex type. A burner of this type is illustrated in Figure 10. With such a burner, a very low turn-down is possible, and it is considered that it would be advantageous for this type of burner to be reintroduced on British cookers to solve the problem of simmering. Burners of this type are often provided with a multi-position control tap which gives four "rest" positions with gas consumptions of, say, 12,000, 3,000, 1,500, and 500 Btu/h respectively. Automatic ignition on the hotplate is at all rates using secondary pilots. Following protracted debates on A.G.A. committees, it is now obligatory that all cooker ovens be fitted with automatic ignition and a safety device. In one ingenious arrangement of oven burner and thermostat using a standing pilot and a heating pilot, below a temperature of 325° the thermostat actuates the flame-failure device cutting the heating pilot in and out so that temperatures as low as 140° can be maintained.

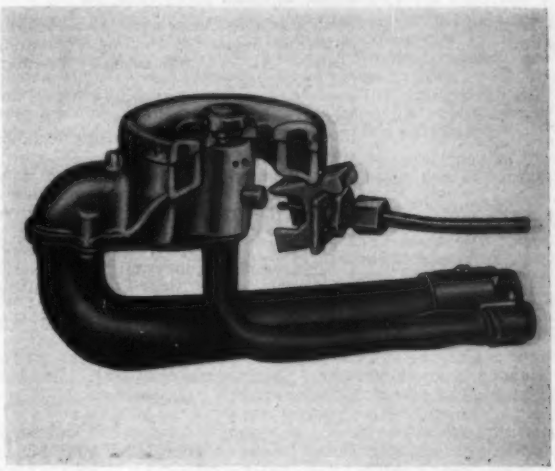


FIGURE 10.—*The "Alltrol" Duplex Cooker Hotplate Burner.*

(C) Water Heating

On water heaters, there is little to comment. The large self-contained storage heater is standard in America and it is easily accommodated in the large basement normally available. The Authors were, however, told that the sale of the American version of the "Ascot" instantaneous multi-point is increasing progressively.

(D) Lighting

An amusing development in America is the reintroduction of gas lighting. It is now a matter of social compulsion for all better-class houses to have a gas standard lamp in the garden or on the patio. The lamps are left alight continuously and thus represent a very useful gas load of about 19 therms/month.

Acknowledgments

The Authors wish to record their gratitude to The Gas Council, the North Thames Gas Board and the South Eastern Gas Board for giving them the opportunity of making the visit to America. They wish to thank all those organizations visited, and the officials they interviewed, for the time and trouble taken to provide them with the information they required. Many contacts were made, and it has been pleasant to renew some of them during return visits paid to the Authors in Britain.

It is not possible, in the space available, for the Authors to list all their American and Canadian hosts, and they hope that it will not be considered out of place to mention particularly Mr. Hodgdon, Mr. Robey and Mr. Kirk of the American Gas Association, who not only provided information from their own organization, but also did much to help with the arrangements for other visits of the tour.

APPENDIX

Itinerary and List of Visits

New York:	American Gas Association Headquarters. Morse Boulger, Incorporated. Brooklyn Union Gas Company. American Society of Heating Ventilating and Air Conditioning. American Thermocatalytic Corporation.
New Haven, Connecticut:	J. B. Pierce Foundation.
Topton, Pennsylvania:	Caloric Appliance Corporation.
Washington:	American Gas Association. Federal Housing Authority. Housing and Home Finance Agency. Office of International Housing. Public Housing Administration.
Cleveland, Ohio:	American Gas Association Laboratories. American Society of Heating Ventilating and Air Conditioning Research Laboratories. Perfection Industries, Limited. Van Dorn Iron Works. Shaker Heights District Heating Installation. Conference with manufacturers of controls, arranged by A.G.A.; including: Baso Incorporated; General Controls Company; White Rodgers Electric Company; Harper-Wyman Company; Minneapolis—Honeywell Regulator Company; Robertshaw Fulton Controls Company. National Warm Air Heating and Air Conditioning Association.
Chicago, Illinois:	People's Gas Light and Coke Company. Institute of Gas Technology.
Urbana, Illinois:	University of Illinois; Research by National Warm Air Heating and Air Conditioning Association and by the Institute of Boiler and Radiator Manufacturers.
Milwaukee, Wisconsin:	Baso Incorporated.
Minneapolis (Min.):	Minneapolis—Honeywell Regulator Company.
Marshalltown, Iowa:	Lennox Industries Incorporated.
Toronto, Ontario:	Canadian Gas Association. The Ontario Research Foundation. John Inglis Company, Limited. Lennox Industries.
Hamilton, Ontario:	Barlin-Scott and Company, Limited (Lincoln Furnaces). Continue-Flow Heating Products, Limited.
Montreal, Quebec:	Quebec National Gas Corporation. McGill University.
Pittsburgh, Pennsylvania:	(G. H. F. only) Koppers Company, Incorporated.

PRESENTATION, DISCUSSION AND REPLY

Presentation

Dr. F. J. Eaton presented this paper and summarized its contents.

Discussion

Mr. J. H. Dyde, O.B.E. (Chairman, Eastern Gas Board):—Nine years have sped by since I had the privilege of leading the British gas industry's Productivity Team to America, and the main part of my Presidential Address to this Institution in 1952 gave my impressions of the American scene and was followed some months later by the team's official Report.

There has been no subsequent appraisal of the extent to which the recommendations of that Report have been heeded or implemented. I can say, however, that members of that team have enjoyed a sense of quiet satisfaction in the fact that quite a number of suggestions have been adopted and developments in many instances have followed in the wake of American practice.

It can be said with some degree of justification that developments would have gone that way in any case, and the only claim that we, as a team, make is that we stimulated interest in this fabulous, expanding and virile American gas industry to the extent that it caused others to cross the Atlantic to see and learn for themselves, and American technical and commercial methods to be studied more seriously so far as their application to British conditions was concerned.

I welcome this most recent factual account of the domestic use of gas in the U.S.A., concentrating, as was intended, on space heating, a load that, we all agree, offers to us the greatest prospects. We are novices in most aspects of this business, and, of course, we on the supply side and the manufacturers of appliances have a lot to learn from the Americans.

The Report states that in 1958 the gas house-heating load had reached 64 per cent saturation; ours is but a fraction of this. They are catering for a mass market and their appliance design and control systems have behind them a vast amount of research and development, and their servicing arrangements years of experience in this field. Under our present almost static conditions we could not hope to rival their standards except perhaps over a long period.

It is no loss of face to accept such a position. The Americans themselves will be the first to admit that their resurgent position has arisen only since the advent of cheap natural gas. I remember talking to a number of chief executives of companies in the North and on the Eastern seaboard, namely, Brooklyn Union, Baltimore, Consolidated Edison, and others who had only recently turned over to natural gas, or were at that time in the process of doing so. They recalled to me the very difficult competitive and financial position they were in during the latter days when their economy was still bound to coal; how their position had been held by the use of oil and other petroleum products for gas making; but that it was not until natural gas came along in quantity that the upsurge began.

Price is a highly significant factor in the pattern of energy consumption. Here are comparisons of consumption between the U.S.A. and Great Britain. The U.S.A. figures are taken from this Report and this country's from the *Ministry of Power Statistical Digest*, 1959.

	U.S.A. (Per cent)	Great Britain (Per cent)
Gas	38·0	7·2
Solid Fuel	13·7	50·0
Oil	33·0	19·9
Electricity	15·3	22·9

I can only say God-speed the first commercial methane tanker to these shores, and success to any scheme that will give us cheaper gas.

The pattern of gas sales in the U.S.A., as typified by the figures given for Chicago, show an average annual consumption per consumer, without space heating, of 350 therms, namely 3·5 times our own. Two obvious reasons can be given for this : (i) price, and (ii) the generally higher standard of living ; more gas is used in the home laundry and for drying and incineration. There are other reasons, for instance the effectiveness of marketing policy.

With space heating, the average goes up a further 1,350 therms/a. It is not easy to make a comparison here, as standards vary, but the most popular installation is a unit of 40,000 to 50,000 Btu/h, and from figures taken out in my Board such an installation yields between 900 and 1,000 therms/a.

Considering that U.S.A. installations are designed for a temperature rise of 85°F, compared with Great Britain's 35°F, I should have expected a larger difference. The reason for this may well be in the better standard of insulation in the American home. Restating the Authors' figures in another form, heat loss in the U.S.A. should not exceed 0·6 Btu/ft²/1°F, compared with 0·77 in Great Britain. It would be to our advantage to campaign with Mr. Gerald Nabarro, M.P., on this very important point of insulation.

Because so large a proportion of appliance sales in the U.S.A. are placed through dealers and contractors, it seems that conditions are created where the liaison with architects and builders can be more complete and effective. Having moved, over the years, to an industry-based selling and service organization, we are now realizing that in this vast potential field of space heating it is necessary to widen our outlets again and embrace the contracting side, namely, the heating engineers and dealers, and to provide a first-class advisory service for them ; assuredly, this is a step in the right direction.

New housing makes an interesting comparison, and I shall quote British figures against those given for American. The Report states that less than 3 per cent of new domestic dwellings are built by local authorities and 80 to 90 per cent of all new housing consists of single-family dwellings, tall blocks of flats, surprisingly enough, being uncommon.

In 1959, in Great Britain, 45·5 per cent of new dwellings were erected by local authorities, the balance being privately developed, and on the local authority side 60 per cent were houses and 40 per cent flats. These figures indicate the importance of our task in having the right sort of trained personnel to meet borough architects and surveyors and housing committees in order to advance the case for the introduction of modern space heating by gas. With these bulk orders, one is either "in" or "out", or, to use Dr. Eaton's expression in another direction, it is a "go" or "no-go".

Since my team, as I like to call it, visited the States, two significant changes in their space heating trends are noticeable there—first, the preference in central heating for the warm-air systems, now approximately 65 per cent of the total, the reason given being the lower capital and installation costs, particularly with the semi-basement type of house. I think this is a point where we should try to influence our architects in the direction of house designs compatible with these systems. One way is to purchase show houses, on new estates, incorporating such systems. A number of Boards are already doing that.

Secondly, there is the big advance in the sale of the independent room heater. My team found some preference in the Southern States, but now, apparently, the sale has extended to the Northern cities, replacing oil-burning and solid-fuel stoves.

My impression is that our own radiant heaters with added convection are superior in design, appearance and comfort conditions to the American counterparts ; but their closed fires with fan-assisted convection are an interesting development and should be taken up here.

Replacing the coal fire in the living-room by an independent gas heater offers us the greatest potential in the space heating field as far as existing properties are concerned, and any development to accelerate this change should be relentlessly pursued.

The team was able to pick up useful information in connexion with other gas loads. There is certainly a growing market in this country for gas-fired incinerators of both the bulk and independent types. My Board has been encouraged, within the last few weeks, by obtaining an order for American-type smokeless incinerators for every ward—27 in all—of a large city hospital.

Much to our chagrin, for we pride ourselves on our sales initiative, we recently had an unsolicited testimonial from the Launderette Organization with a quarter-page advertisement in the local paper, which used the caption : "Every day a drying day in 1961", followed by a statement which read : "We have installed gas-heated Tullis (American-type) tumbler dryers at both our launderettes—a 9 lb load ready in six minutes"—a salutary reminder that our finger is not always on the pulse, for this newspaper advertisement was the first we knew about this installation.

The Report invokes comments from so many angles that one must necessarily be selective, and I have chosen that of controls on which to conclude.

The American manufacturer, with his mass market to which I have already referred, has been able to achieve a degree of precision and reliability in the manufacture of controls at reasonable costs that leaves us way behind. The use of the bi-metallic flame-failure device in favour of the thermo-electric device has been abandoned except for minor subsidiary functions.

Controls are an essential feature of many of the appliances with which we hope to break into new markets and to retain existing business. If they are unreliable, we jeopardize consumer goodwill, up go our servicing costs, and appliances could even be dangerous. Therefore, I plead for a re-examination of this situation. At the same time, I do not wish to imply that there are no first-class controls available on the British market. Of course there are. I ask for an examination of the selection and extension of use of newer systems. Do not let us delude ourselves : controls in many instances are no longer gimmicks.

Within the range of cookers we offer for sale, we must have a reliable fully automatic cooker to meet electrical competition. Several have already appeared on the market, but one or two failures have, on my own observation, shaken the confidence of our salesmen. This is bad, and conditions must be created whereby our industry can place cookers of the type we need on the market.

In thanking the Authors for their informative and well-presented paper, may I express the hope that we shall see a return visit from American and Canadian teams. There is evidence that we can make a contribution to their knowledge in the development of special flues, such as the Se-Duct, and the balanced flue, and in design aimed at increasing the thermal efficiency of some appliances. They are still a little profligate in the use of gas. Because of their low gas prices, efficient appliance design has not quite the same significance to them as it has to us.

Incidentally, I am pleased to learn that I should stand high in American social life because I have an attractive gas lamp at my house drive-in !

Mr. N. Barnes (Chief Research Engineer, Ascot Gas Water Heaters) :—This paper gives a most valuable picture of North American practice, and I am very pleased to have the opportunity to comment on it from the point of view of a manufacturer with appliances approved by the American Gas Association and Canadian Gas Association, and selling " over there ".

Regarding gas conditions, their heavier and sulphur-free gases impose more onerous design requirements in certain respects, particularly safety controls, but less onerous in others, such as heat exchangers.

Their type of market—that is, large with high-living standards—has called for quantity production of elaborate and highly automatic appliances. This presents a " nice " problem to an importer, who must seek and obtain a specialized market since he cannot compete in price with an identical mass-produced American product.

I like the picture of the American Gas Association. The manufacturer sees a tougher side of this than the Authors when obtaining his " go "/" no-go " approval, but, although the approval specifications set a high standard, a technically good appliance from abroad can be cleared. I have mentioned before that the American Gas Association carries out research and approval, but avoids the intermediate stage of development, which could cause difficulties with manufacturers. Our practice is the reverse, and some very successful projects have been the result. Regarding this and some other aspects—perhaps even the absence of testing fees at Watson House—I agree with the Authors that each testing system is best suited to its own country.

American central heating is basically similar to ours, with its main division into " warm-air " and " hot-water " systems. May I digress here on this terminology, which is very bad. A hot water system is easily confused with a domestic hot water system, and also provides warm air to some extent. The Americans have faced up to this by using the term " Hydronic ". One highly placed member of our industry, whom I will leave anonymous, has suggested that we complete their thinking by calling the other system " Aeronic ". The terms " Wet " and " Dry " are used ; they are very neat, but, perhaps, have incorrect implications regarding humidity. My own suggestion is to define according to the method of heat distribution and use the terms " Waterpipe " and " Airduct ". I should in any case solicit support for improved wording.

The company with which I am associated markets a hydronic boiler in North America, where, for many years, forced circulation, low thermal capacity bodies and highly responsive controls have been used. The company took this trend further by adapting an instantaneous water heating body to give an even lighter unit that was the first to be wall-mounted, thus providing the necessary special features I have mentioned.

The benefits of the higher water temperature permitted by the mains-fed hydronic system are great, but are not likely to be available here in the near future in view of our by-laws requiring tank supply.

I was very interested in the comments on balanced-flue and Se-Duct appliances, which instance development by The Gas Council and manufacturers. Their slow application in America has been attributed to the absence of a firm requirement, but I suspect that the reason may be the problem of clearing them for the heavier gases, which has now been solved for a natural gas Se-Duct in France. If this should be the case, so that they proceed with the assistance of our information, I should be very pleased, since there is a tendency for our friends in America to think that we lag behind them in gas technology, with which I do not agree.

American development of controls to provide the safety standards and automation mentioned has resulted in many excellent components : for instance, thermocouple devices, quiet solenoid valves, snap-acting and modulating thermostats, *etc.* Their combination units are also extremely clever : for example, alternative arrangements of flame-failure device, governor, solenoid valve, thermostat, *etc.* Complex controls are unlikely to be used to the same extent in Britain, but their incidence is increasing as particular appliances become more automatic : for example, central heating units.

The instantaneous water heater is another appliance marketed in America by my company. The bulk American requirements are for storage heating, and the instantaneous type fulfils the specialized requirements referred to. Examples of its use are in motels where the demand is highly variable, and for car-washing installations.

Finally, the different conditions in America and Britain may limit extensive import and export business, but I think that there will be an increasing amount with suitable specialized articles. This will provide a live background for the exchange of technical information, which I consider most important. Therefore, I thank the Authors very much for their most interesting paper, which symbolizes a closer contact between the gas authorities concerned, and I look forward to seeing this developed further in the future.

Mr. W. G. Phillips (Watford ; Commercial Manager, Eastern Gas Board) :—There are many matters mentioned in the paper upon which I would like to comment, but I shall select what I feel are the more important.

Whilst the main object of the Authors' visit was space heating, tumbler dryers and incineration, a number of references are made in the paper to the cooking load, particularly the extent to which business is being lost to electricity, notwithstanding the favourable price advantage of gas over electricity, a ratio of 2, 3 or 4 : 1. Here, surely, is a lesson for us. In spite of the high average annual consumption per consumer, due to the heating load, the cooker is considered vital in the United States, as in the United Kingdom. Experience proves that a customer who chooses gas for cooking is most likely to use gas appliances for water heating, refrigeration, clothes drying and house heating. In essence, the gas range acts as an anchor in securing all the other important uses for gas in the home. There could not be a better way of expressing an idea of the importance of the cooking load.

It is true that the electricians are gaining in this field, and I have with me the statistics showing the production of gas and electric cookers in the U.S.A. for the home market for each year from 1954 to 1960. These figures are further broken down into built-in and free-standing models. Two significant facts emerge from them : the proportion of gas to electric production falls from 60·5 per cent in 1954 to 55 per cent in 1960, whilst the proportion of built-in models to total production for gas increased from 2·5 per cent in 1954 to just under 20 per cent in 1960, and for electric 7·5 per cent in 1954 to 43·5 per cent in 1960. The President of Caloric is said, in the paper, to have given the reason for the loss of business to electricity that the gas industry had lagged behind the electricity industry in modernizing gas ranges. This seems strange when one knows that the use of electricity for burner ignition, automatic timing of oven, *etc.*, has been in vogue in gas cookers in America for years. The British gas industry's Productivity Team's Report made mention of this tendency of the American gas industry to use electricity for ancillary control of appliances, and suggested that we might well follow suit. Mr. Klein's statement just gives one the measure of the American problem and, in my view, a problem of the same magnitude that we must meet here now.

The paper refers to the built-in cooker as the present fashion. It would seem that the Authors are rather dismissing this type of cooker as a passing fashion ; they do not say so, but it is implied. I suggest that the above figures show that this is not so.

The ranch-type and the split-level-type of house are, as the paper states, popular in the United States. Copies of them are being built in many parts of this country. There are signs of an increasing demand from architects, builders and house owners for the split-level cooker in this country. Our industry is at a disadvantage as there are few gas versions, whilst the electricians are already importing the " Fabulous Tappan ", " Moffat " and several others from across the Atlantic.

It should be remembered that there are problems associated with marketing built-in cookers that do not apply to the " common or garden " free-standing cooker. The sale of built-in appliances revolves around the cabinets, and complications arise due to sub-contractors, carpenters, plumbers, *etc.* In other words, in marketing built-in appliances, it may be necessary, to an extent, to go into the kitchen furniture business. This may be one of the reasons why the American gas industry lost some of its business to the electricians. Do the Authors agree that this was a contributory factor? There are, of course, two markets for the built-in cooker : (i) the glamorous remodelled complete kitchen costing, say 3,000 dollars, and (ii) the packaged kitchen costing not more than 500 dollars. Both these markets exist in this country.

There are three developments in the American gas cooker not mentioned in the paper, and I should be interested to know

whether they were covered by any of the discussions on visits paid to manufacturers. First, the flush-top pyroceramic burners built into the kitchen countertop, on which food can be directly cooked without utensils ; secondly, the power burner, in which the gas and air is, by means of a fan, mixed in the right proportions so that no secondary air is required for combustion—combustion can then take place in a covered space, with greatly increased efficiency ; thirdly, the " Kook-n-Heat " gas range, which is a gas range with a room heater attached.

A considerable amount of research is being sponsored by the American Gas Association in thermo-electric and thermionic devices whereby gas can be used directly for generating electricity, and the thermo-electric method is mentioned, in Section X of the paper, for use in operating the fan and controls on an air heater. This would seem to be a worth-while development. Would the Authors give their opinions as to possible application in this country ?

Research is also being carried out on pulse combustion heaters, with 15 to 20 per cent increase in efficiency. Did the Authors see any examples of this rather noisy method of combustion, and do they think that it can be developed into practical fields of utilization?

The Authors seem a bit pessimistic in their comments on air conditioning ; whilst gas may, at the moment, be getting only a small share of the market, tremendous efforts are being put into its development. I do not feel that even in Britain it should be ignored. It is, of course, becoming quite usual to air-condition public and office buildings in this country, not only from central units, but by means of window-type units. Is this type of gas-operated unit being developed in the U.S.A.?

The remarks on tumbler dryers are most interesting and have a significant bearing on development over here. I am under the impression that, as yet, electric models outnumber gas by about 1·8 to 1·0, but gas is fast overhauling electric because this ratio was, I think, in 1954 something like 4 to 1. I think the most significant statement in Section XI is that the success of gas-heated tumbler dryers is being achieved in spite of the cost differential ; speed of operation is the essence of success, a situation that can apply in this country too.

I must not end my remarks without a reference to the resurgence of gas lighting. The Authors say it is " amusing ". I am not sure whether we should just pass it off like this. Apart from the status symbol of having a gas lamp outside one's door, or on the patio, gas lamps are being used outside commercial premises, on airstrips, car parks, and for a host of other applications. The record peak lighting year in America was 1914, when there were 300,000 street lights. It is estimated that today there are 750,000 outside gas lights.

Mr. L. W. Andrew (Director, Watson House Centre, The Gas Council) :—I am breaking a golden rule in speaking on a paper in which I have a vested interest, but I feel very strongly about the value of the visit described by the Authors. It has brought home to me very much that one can do so much more and so much better by personal contact than merely by correspondence. I believe that the personal contacts of the team have re-established a great mutual respect with the technical people in America.

By their visit, the Authors have been able to appreciate American achievements without necessarily accepting the suggestion that, because something is bigger it is, therefore, better. I believe that by going to America and talking to the people concerned, the Authors have been able in the paper to put into perspective what we can learn from the Americans and what they can learn from us.

It seems to me that there are two main aspects in which we can learn from America. The first is to go there and take advantage of the aspect of their work in which they have a wider and longer experience than we have ; for example, in central heating, warm-air heating, incineration and drying. The Americans have had a start over us in these fields, and they have had more experience. Secondly, of course, we can pick up new ideas.

I shall not go into the details of the items mentioned in which we might learn lessons. I emphasize, however, the point made by Mr. Dyde, that this should be a two-way traffic. It became quite clear that, whereas, on the one hand, there is a great deal of information that is of immediate value to us, on the other hand the Americans were impressed by a number of aspects of our work in which they could profitably come over here and have discussions.

I have in mind such items as balanced-flue appliances, the whole question of intermittent heating, and the comfort standards that people really like, closed convector fires and discussion on testing methods and standards.

Quite clearly, one must look back upon a visit of this nature and ask what has been the profit from it and what we are going to do about it. There are three aspects of this : first, it is clear, from the paper, that there are technical lessons to be learned. Our job is really to make use of the information that we have got. Every aspect of the report of the visit is being considered technically in detail. In addition, all the items have been presented to the various committees at the highest level in the gas industry. We shall, therefore, extract the maximum value from the information obtained.

Secondly, it seems clear that the right atmosphere has been created for a return visit, certainly by the American Gas Association to us. This would be an invaluable step.

The third point is one that Mr. Dyde did not mention. The Authors' visit should be the beginning of an exchange of information, and we should follow up what was almost entirely a space heating mission with a visit on the other major aspects of cooking and water heating.

Mr. A. J. Adam (Chief Chemist, R. and A. Main, Limited) :—I am very pleased to be able to take part in the discussion on this interesting paper, since I, also, paid a visit to the United States in the autumn of 1960, following earlier visits in 1951 and 1957. The Authors were primarily concerned with the domestic use of gas, and more particularly with gas for space heating, whereas I went there, as an appliance manufacturer, to learn what I could of developments in this field. The fact that I looked at the American gas industry through another pair of spectacles does not mean that my general impression was different, but some things did, perhaps, impress me to a greater or lesser extent than they did the Authors, and any comments I make should be interpreted in this light.

The Authors draw attention, early in their paper, to the conditions of gas supply and the pattern of sales, and they rightly point out that gas has succeeded in capturing a very large share of the house heating load. The Authors do not, perhaps, make quite enough of the fact that, in markets other than space and water heating, gas does not have an easy time in America. It seems at the moment to be losing the gas cooking load, and in all the other fields it really has to struggle hard. Even in space heating and water heating, competition from electricity is quite severe.

In the Southern States in particular—where not very much space heating is required, and the heat pump can be used also for air conditioning in summer—the General Electric heat pump system is a serious competitor. Even electric under-floor heating is a competitor in the Northern States.

The price of gas is low ; there is no question about it. The Authors quote a figure of 11*d.*/therm, but in some places it is even less than this. The figure of 11*d.*/therm has to be related to an average level of wages and salaries that is, perhaps, 2·5 times what it is in this country.

In spite of all this, people do not necessarily choose a gas appliance when they go to buy one. In an affluent society, the price of the fuel is not necessarily the deciding factor. America is very much an affluent society at the moment, and a constant effort is necessary on the part of the gas industry in America to keep the image of gas in front of the American public. The American Gas Association spends millions of dollars annually in doing this. It employs all the aids of modern publicity—television, newspaper advertising, and so on. One cannot overemphasize how hard it has to struggle.

There are pressure groups in the United States Congress who are trying to limit the sale of gas. One gets the impression that America is a " free-for-all " economy and that things like this cannot happen ; but, of course, a lot of the electricity interests own very large coal mines, which they want to keep operating profitably. There is at the moment a substantial pressure group operating in the United States, and in Congress, which is trying to get legislation passed that will prevent gas being used for certain purposes, notably for power generation by electricity suppliers who do not have coal mines of their own.

One thing omitted from the paper is any reference to the effort that has been made to re-establish as a live force gas refrigeration in America. Some years ago, the Servel Company, which used to

make absorption-type units, went into liquidation because it could not stand competition from the compressor-refrigerator manufacturers, and the gas industry felt that it was suffering by not being able to offer refrigeration as well as space heating, water heating, cooking, *etc.*

The American Gas Association and other corporations persuaded a number of appliance manufacturers, particularly R.C.A. Whirlpool, which was originally a supplier of electrical appliances, and Norge to produce large gas refrigerators, and magnificent appliances they are. They have performances as good as those of the large compressor refrigerators, although to do this, because of the inherently much lower efficiency of the absorption system, they have had to resort to considerable complexity and high cost.

R.C.A. Whirlpool makes a 14 ft³ model that uses three circulating fans, all driven by electricity, and a number of electrical controls, and sells this model at a price of 700 dollars, which is considerably more than it charges for its comparable compressor-refrigerator. The claim is made principally that the running cost, even with the lower efficiency of the appliance, is less than that of the compressor-refrigerator. These big compressor-refrigerators, even in America, cost several dollars a month to run, and the claim is made that, by running refrigerators on natural gas, money can be saved. The R.C.A. Whirlpool and Norge organizations are making a considerable effort to sell these appliances, but I do not think that many people expect them to be very successful. Certainly, I do not think that there is any market at all for appliances of that kind in Britain. With our price of gas, the running costs would be quite fantastic.

Mention of these appliances leads me, however, to another point, which particularly impressed me ; this is the extent to which electricity is used on American gas appliances. It is certainly true that thermo-electric and thermionic devices are being developed in America, but, by and large, the Americans are completely uninhibited in their approach to the use of electricity on gas appliances. If it helps to sell gas, then by all means they use electricity.

While I was in America, I was able to attend the American Gas Association Convention, which is the nearest thing the Americans have to the Annual General Meeting of The Institution of Gas Engineers. In connexion with that Convention, they hold what they call a " Festival of Flame ", which is held every two years. In this case, it was held in the Convention Hall of Atlantic City which is a fine building. There was a magnificent display of new products and devices that the American gas industry as a whole and the American appliance manufacturers were putting on the market.

It is fair to say that the majority of those appliances simply could not work if electricity were not available. Ovens and hot-plate burners were being used with circulating fans. Many of them had electric controls and ignition. Everywhere that electricity could help to make gas do a better job, it was used, and no one thought twice about doing it.

While talking about the American Gas Association Convention, I can, perhaps, dot one very small " i " in the Authors' paper, concerning the duplex burner. Duplex burners have, of course, been used in America for very many years, owing to the large port area required with natural gas and the difficulty of getting a satisfactory turn-down ratio. At the Festival of Flame, several manufacturers were showing, as the latest productions of their research departments, simplex burners that could be turned down from 12,000 to 500 Btu without the use of any duplex tap.

There is little that I can add to the Authors' review of space heating methods beyond confirming that much interest was being shown at the American Gas Association Convention in balanced-flue systems. We were left also with the impression that there was really little demand in the United States for radiant heat as we know it. The impression was left with us—and it was confirmed when we visited quite a large number of department stores and inquired about the type of people who bought the radiant heaters that are still available—that it was the poorer sections of the community that tended to buy that kind of appliance. Warm air is overwhelmingly the choice when there is anything more than the absolute minimum of first cost to be considered.

When going to America, one tends, perhaps, to have a little feeling of envy with regard to the conditions under which the American gas industry operates. But the British gas industry is going through a transition period, and we hope that in the not distant future it will be reinvigorated.

At this time, therefore, we in Britain could all do much worse than adopt the slogan of the managing director of the American Gas Association : " Every good service, good product, good institution, good organization, good individual or good idea has to be sold all the time."

Dr. W. Davidson (Director of Research and Development, Heating Division, Powell Duffryn, Limited) :—In opening the discussion of this most interesting paper, Mr. Dyde has already high-lighted the importance of a very high standard of insulation, and there must be everything to be said for the adoption of this in Britain.

I suggest, however, that we could not, with success, adopt the comparatively low rates of air change, since, with our higher humidities, this would give rise to condensation and it would be better to retain our normal standard of 1·5 to 2 air changes per hour.

These higher standards of insulation, if attained, as in the U.S.A., by using low-thermal-capacity liners for the inner surfaces of the outer walls will, in addition to reducing the heat losses, give a substantial increase of the inner surface temperature of the wall. This will reduce the rate of loss of heat from the body to these walls, giving increased comfort and eliminating " that chilli feeling ".

Referring to perimeter heating, I should like to ask the Authors if this system is more favoured in the areas where winter outside temperatures are very low. I suggest that this system, while suitable for continuous heating as practised in the U.S.A., is less satisfactory for intermittent heating, which is almost universal in our homes. With the latter method, due to the temperature drop through the comparatively long duct runs, cool air is likely to be discharged into rooms, particularly at the beginning of each heating cycle. For this reason, I feel that the more compact and, incidentally, cheaper system, where the warm air is discharged from the inner walls and is blown towards the outer walls, is likely to find greater favour in Britain.

It is interesting to note the increase in the use of baseboard heating, a system the Americans copied from us many years ago and which is now being re-introduced into this country.

Finally, it is obvious that the Authors have brought back a wealth of information, which they could not possibly hope to include in such a brief paper. I suggest that they be asked to publish a much fuller account of their investigations, or that we should have a whole-day or, better still, a two-days conference to discuss the most interesting subject that they have so ably introduced. This would be very profitable to all concerned with domestic central heating.

Oral Reply

Mr. G. H. Fuidge made an oral reply to the discussion, but the import of his remarks is included in the Authors' joint written reply.

Written Reply

The **Authors**, in reply wrote :—The Authors are a little sorry, if they have given the impression that Britain is so far behind the Americans in appreciating the problems of space heating by gas. One of their reassuring experiences was that the gas industry in Britain has developed along lines of real progress similar to those seen and examined in the U.S.A. and reasonably independently of direct American influences. It is admitted that the Americans have had much more experience of application of warm-air heating, for example, but in a somewhat different way and under the influence of different conditions and sets of circumstances. British gas engineers have much to learn, but the Authors cannot agree with the assumption that we in this country are " novices ".

Mr. Dyde makes many helpful comments and the Authors would support any move to re-state the tremendous importance of thermal insulation of the houses themselves. The lower the overall heat loss, the better the relatively expensive and responsive fuels will compete. As regards temperature rise comparison, the design figure is higher in certain parts of America, than the 85°F given in the paper, but it seemed that the value given was a fair average.

The Authors agree with many of Mr. Dyde's other comments, such as the superiority in design and presentation of the English convection/radiant heaters, with, perhaps, the reservation that the present-day designs in the two countries were approached from different directions and with somewhat different objectives.

As regards the use of tumbler dryers in commercial launderettes, this load has developed rapidly and the Authors can assure Mr. Dyde that the Watson House Centre Committees have been fully informed of the progress made : for example, the Tullis Dryer has been tested, slightly modified and reported on by Watson House, as have a number of others. Launderette managers have made several visits to Watson House for exchange of information and experience.

Mr. Barnes' comments are well appreciated by the Authors, in view of his own very close contact with the American scene. After due consideration, the Authors agree that it would be wrong to adopt the somewhat " ruthless " " go " and " no go " approach in this country, although certain advantages of this procedure are recognized. They prefer the more co-operative testing and development that takes place between British gas industry laboratories and the appliance manufacturers. Long may it continue this way.

The vexing problem of describing precisely different methods of central heating has certainly not been solved in a manner acceptable to all. It is a pity that an authoritative decision and opinion cannot be found, but perhaps this matter can be dis.ussed with the heating industry.

The Authors were pleased to see several successful installations of instantaneous-type water heaters, and these were of British or, at least, Non-American origin. They support wholeheartedly Mr. Barnes' contention that Britain does not lag behind the U.S.A. in many aspects of gas technology. It is a pity that there are too many people in the British gas industry that all too willingly think that the other fellow is cleverer and better informed. The gas industry here too often writes down the achievements of its own technologists.

Mr. Phillips raises a number of questions, one of which is clearly of importance to any industry that might benefit by the inclusion of electric power brought in as a separate service to the appliance. In the U.S.A., the devices using the heat energy of the gas to generate electricity of low power were at an interesting stage of technical development. So far, efficiency was very low and capital cost very high. The scientific view was optimistic that the technical problems would be solved successfully in a few years and low-power thermo-electric generating units would become a reality. Commercial opinion was much more cautious and, indeed, sceptical as to whether or not the complete solution was in sight. For special control systems, application would be well advanced, but development of successful power-generating units was " way ahead " in the future.

If, in connexion with air conditioning factual statements referring to technical assessments are regarded as pessimistic by Mr. Phillips, this is a little unfortunate. Conditions in the U.S.A., and the demand for air conditioning, are very different from this country, and yet, with all the advantage of price and availability of fuel, the American gas industry is obtaining but a very small share of the market. Mr. Phillips knows the thermodynamic differences, and the limits imposed by these differences in the application of the two main forms of refrigeration cycle, and there is no need to re-emphasize them. The Authors agree, wholeheartedly, that one should see how one fares in this country, by introducing equipment of American design. Steps have already been taken to implement this recommendation.

Mr. Adam is supported by the Authors as to the intensity of electrical competition in all fields of the U.S.A. The electrical industry is extremely active, not only technically but in subtle and impressive publicity and propaganda. The Authors mention, for example, the success of electric space heating by direct methods in certain parts of the U.S.A., and this is giving some concern to the gas industry there. The Authors heard no mention of underfloor heating by electricity of the form that has become so popular in this country, and certainly it did not yet seem to be receiving much consideration. No mention was made of it by the Federal Housing Authorities at Washington, nor by the Heating and Ventilating Association, nor by the American Gas Association.

With regard to air conditioning, electrical power predominates, and the reply to Mr. Phillips perhaps covers this. One word of caution, however : the heat pump succeeds only where there is a reasonable balance between the demand for heating and cooling.

The Authors regret that space did not permit a fuller reference to refrigeration, but agree with Mr. Adam regarding the resurgence of interest in gas-absorption-type refrigeration. Another reason for the submergence of the Servel Company was that all the interest in gas-absorption refrigeration was centred in one organization, but now others have become active, as mentioned by Mr. Adam.

The Authors support Mr. Adam's view that the use of electricity with gas appliances has increased the field of application of gas and led to many successful developments. The technical arguments for the increased application of electrical power to gas appliances are extremely strong, and particularly so when the gas heat service has special advantages, in comparison with an all-electric alternative, in fuel cost and effectiveness.

The Authors always respect a contribution from Dr. Davidson, and agree, in the main, with the points he makes. As regards the use of low-thermal capacity linings, the importance of this has been raised a number of times in previous papers and contributions by one of the Authors*, and, therefore, Dr. Davidson's suggestion is fully acce.ted.

It was the Authors' experience that perimeter distribution of warm air was preferred in all instances and areas in America, but discharge by shorter ducts from inside positions was still used where price was an important factor. As Dr. Davidson remarks, it may well be that, with the more temperate climate of Great Britain, the refinements produced by perimeter discharge of the warm air may not be so important as in areas where more rigorous conditions exist. Nevertheless, as a result of their American contacts and studying the full and extensive literature on this subject available in the U.S.A., there is little doubt in the Authors' minds, that comfort conditions would be better with perimeter distribution.

The Authors will do their best to complete and issue a full report.

* Wills, D. R. Intermittent Space Heating. *Jt. Proc. Brit. Jun. Gas Assoc.*, 1952-53, 36, 201. Wills, D. R., and Chance, P. R. A Comparison of Heating Systems in Two Occupied Houses. *Gas Council Res. Comm. GC42. Trans. Inst. Gas Eng.*, 1957-58, 107, 434.

News from the Gas Industry Overseas

Association Technique de l'Industrie du Gaz en France

It is with great pleasure that the Institution records the election, to Honorary Membership of the Association Technique de l'Industrie du Gaz en France, of its former Secretary, Dr. W. T. K. Braunholtz, O.B.E., M.A. This election was announced and enthusiastically confirmed at the 78th Conference of the Association held at St. Malo.

Société Suisse de l'Industrie du Gaz et des Eaux

The 88th Annual General Meeting of the Swiss Association of Gas and Water Engineers, held at Brunnen on 8th to 10th September, 1961, was attended by about 260 members and visitors, together with a number of ladies. The Institution of Gas Engineers was represented by the President and the former Secretary, and there were also present official representatives and members of the national gas associations of Austria, Belgium, France, Germany and Holland.

The programme included a short Presidential Address, the election to Honorary Membership of the Association of Dr. H. Deringer (Winterthur), a Past President, for his outstanding services to the Swiss Gas Industry, and the presentation and discussion of the following papers:—

(1) "Technical Problems of Town Gas Production Based on Petroleum Oil." by Dr. H. Deringer.

(2) "Economics of Town Gas Production," by Mr. A. Bolzinger (Paris).

(3) "Future Supply of Raw Materials to the Swiss Gas Industry," by Dr. L. von Planta (Basle).

Technical visits were also arranged to various Works in the neighbourhood.

Abstracts of Overseas Papers

The full text of articles abstracted below may be consulted in the Library of the Institution.

State of Co-ordination in the European Energy Economy

F. Burgbacher. *Gas- u. Wasserfach*, 1961, 21st July, 789-794.

The Author reviews in detail the present position in regard to a co-ordination of energy supplies on the Continent of Europe. This is complicated by the existing Montan Union (coal), Euratom (nuclear energy) and the Common Market (gas, electricity, water, oil), as well as by the different energy situation (including nationalization and private enterprise) in the various countries. An advance has been made by the setting up of an Interexecutive Commission, which has already made recommendations concerning a basic price for coal, and other economic factors. Coal might be protected either by imposing duties on competitive fuels or by subsidies. The Author discusses further problems arising from competition with oil, which depends essentially on the pattern of usage (as crude oil, motor fuel, heating oil). Increasing steel demand will increase the amount of available coke oven gas, but a more important consideration is the effect on the gas industry of available supplies of natural gas. It would be a great advantage to the energy economy of the Common Market if a comprehensive European gas grid were installed, receiving natural gas from France, Holland, Federal Germany, Italy and the Sahara. Much has already been done towards a European electricity grid, and oil will be increasingly distributed over large areas by pipeline. Atomic energy need not be considered economically until 1975, when the energy balance will be roughly 30 per cent coal, 20 per cent gas (including natural gas) and 20 per cent electricity. The maximum co-ordination of energy supplies is of vital importance to both the economics and the internal strength of Western Europe.

Short Survey of the Swedish Gas Industry, 1960

C. Lindgren. *Svenska Gasverksföreningens Månadsblad.* 1961, August, 66-69.

Sweden has no natural gas deposits and, owing to the great distances between built-up areas, no long-distance transmission grid. Wood and peat are indigenous, but coal and petroleum are imported. There are 22 gas works, all municipally owned, having a total annual production of about 310 mill. m^3 of coal gas with an average calorific value of 4,300 k.cal/m^3 (actually ranging from 4,080 to 4,350). Town gas is made mainly from coal imported from England, the U.S.A. and Western Germany, but in recent years petroleum products have been increasingly used as raw material. Practically no water gas is made, but some producer gas which, enriched with liquefied petroleum gas or naphtha, is extensively used as peak-load gas. Coke production is about 485,000 tons annually, and the number of meters is 603,000 (out of about 2·4 mill. households). A table of statistical data for the individual gas works is included.

Development of Public Gas Supply in 1960

Gas- u. Wasserfach, 1961, 7th July, 737-739.

The annual report of the Federation of German Gas and Water Works shows 1960 to have been a record year for the gas industry in Germany. The quantity of gas supplied in the Federal Republic was 16·8 milliard m^3, or an increase of 6 per cent over 1959. After a period of comparative stagnation, a definite expansion is indicated, the provisional figures showing increases over 1959 of 5·2 per cent for domestic purposes and 7·0 per cent for industry and commerce. About 170,000 additional households have been connected to the gas supply, bringing the total (including West Berlin) to 7·1 mill. The results have not been equally satisfactory for all undertakings, depending upon the severity of electrical competition. Whilst coal still represents 85 per cent of the raw material for gas making, the report reviews the trends in the use in public gas supply of oil gas, natural gas, refinery gas, liquefied petroleum gas and coke oven gas, and refers to the possible supply to Germany of natural gas from Holland and the Sahara. The importance for further development of gas-mindedness, marketing and service is stressed.

Search for, and Recovery and Supply of, Natural Gas in the Federal German Republic

W. Kessler. *Gas- u. Wasserfach*, 1961, 4th August, 849-856.

The first major discovery of natural gas in Germany was in 1911, and this gas was used by the Hamburg Gas Works until 1923. The natural gas industry in Germany only started, however, with

the discovery, in 1938, of the important deposits at Bentheim. Since then, a number of gas wells have been opened up, at depths of up to about 10,000 ft. The Author discusses the origin and nature of these deposits and the methods used in prospecting, recovery and conditioning. Geological and geophysical exploration can indicate where favourable conditions exist, but the presence of gas can only be proved by actual boring. The total recovery of natural gas in Germany in 1960 was about 448 mill. m³, and this was supplied mainly to individual factories or gas undertakings, as follows :—

	Per cent
Gas Works	About 41
Iron and Steel Industry	About 29
Chemical Industry	About 23
Miscellaneous	About 6
Internal use	About 1

Natural gas at present represents only 0·4 per cent of the total consumption of primary energy in Germany. In respect of the gas industry alone, natural gas and petroleum gas represent about 8 per cent of the total supply from coke ovens and gas works. Encouraged by recent discoveries in Holland, the search for natural gas in Germany is being systematically pursued, boring depths of more than 16,000 ft being envisaged.

The Crossing of Coldwater Creek

W. H. Donnelly and E. V. McMullin. *Amer. Gas J.*, 1961, August, 23-27.

A new pipeline, to operate at 880 lb/in², with a capacity of 200 mill. ft³/d, had to cross a large drainage canal 150 ft wide and carved out of solid limestone. For reasons that are given, it was decided to adopt an arch-type design, and the paper describes in detail, with drawings and photographs, the construction and erection of the crossing. The design adopted was a double arch of twin lines of 16 in. o.d. API 5LX42 pipe with a wall thickness of 0·375 in. and a minimum yield of at least 42,000 lb/in². It was constructed in two halves, each 80 ft long, with a vertical rise of 20 ft, and only a centre weld to be made in the field. The 80 ft segments were fabricated in the shop and 100 per cent radiographical inspection applied. To withstand wind loading, the two circular segments were inclined together at the centre of the arch from a spread footing at the base. Erection was completed in one day, and on the following day the pipeline was welded to each base end and hydrostatically tested.

Ventilation of Rooms in which Flueless Gas Appliances are in Use

P. Faudier. Ass.Tech.de l'Ind. du Gaz en France, Congrès, 1961.

Detailed results are given of an investigation of the effect on conditions of ventilation and hygiene (determined primarily by the concentration of carbon dioxide) in premises in which flueless gas appliances are in use. The appliances used were an instantaneous water heater, a cooker and a hotplate, in simultaneous, continuous or intermittent operation, in a room of 8 or 16 m³ capacity in which the renewal of air could be effected by different means commonly met with in practice. The test installation is described, with illustrations, together with details of the experimental procedure. The results for each set of conditions are recorded graphically. Renewal of air by thermal ventilation is the principal factor, but there is also found, in some cases, a vertical heterogeneity in the carbon dioxide concentration that permits of lower rates of air renewal. The size and disposition of ventilating orifices is discussed, and it is stressed that combustion products should always be removed in the upper portion of a room. Desirable air-renewal rates are suggested. The influence of wind is also considered.

Personal Notes

Appointments

(a) By Area Gas Boards :

SCOTTISH GAS BOARD
Central and Northern Divisions—
Divisional Commercial Sales Officer : **W. T. Lane**

NORTH WESTERN GAS BOARD
Central Lancashire Group
Bolton/Farnworth/Worsley Districts—
District Distribution Engineer: **J. C. Evans**

EAST MIDLANDS GAS BOARD
Notts. and Derby. Division
Long Eaton/Ilkeston District—
District Distribution Engineer: **T. H. Wilson**

WALES GAS BOARD
Brynmawr and Blaina Undertaking—
Engineer and Manager: **H. Potter**

EASTERN GAS BOARD
Cambridge Division—
Industrial Gas Engineer: **E. J. Bell**

(b) General:

Mr. A. K. Basu, B.Sc., B.Ch.E. (AM) has recently taken up an appointment as Senior Chemical Engineer with the Industrial Consulting Bureau Private Limited, India.

Mr. J. H. Roditi (A) is now Area Manager for Contract Operations, covering North African territories, with the Mothercat Group of Companies. He is also maintaining his association with Kellogg International Corporation as a private pipeline consultant.

Retirements

Mr. C. A. Macleod (A) has recently retired from his position as Sales Director with R. and A. Main, Limited.

Mr. R. C. Ruggles (M) has recently resigned from his position with the Bombay Gas Company, Limited, and is returning to England.

Addresses Required

The Council would be grateful to receive the present addresses of the following members, last heard of in the places given in brackets :

Mr. W. G. Bignell (Eastbourne).
Mr. D. J. Bradley (London).
Mr. E. Clark (Bridlington).
Mr. S. W. Hayes (Braunton).
Mr. D. Helliwell (Halifax).
Mr. P. W. Hugh (Middlesbrough).
Mr. C. Kay (Cambridge).
Mr. N. P. Shepherd (London).
Mr. A. W. Somerville (Bury).
Mr. A. M. Steel (Gutersloh, Germany).
Lt.-Col. T. C. Whimster (Ashford).

List of Current Gas Works Safety Recommendations

Following is a list of the Institution's current safety recommendations constituting the loose-leaf publication entitled " I.G.E. Safety Recommendations ".

Whilst the list includes additions sent in August and September to bring up to date all copies of the work whose separate location is registered at the Institution or which are serviced through Gas Board channels, the attention of individual holders of the loose-leaf binder is drawn to Supplement V of the 21st Report of the Chairmen's Technical Committee : 1959-60 (Communication No. 577 of the Institution), which is reproduced in the *Journal* of The Institution of Gas Engineers, Vol. 1, No. 1, January, 1961, pp. 39 and 40, and lists amendments to I.G.E. Safety Recommendation G17 (" Recommendations for Gasholders). A new safety recommendation to replace G17 will be issued as soon as possible.

The separate sectional contents tables of each loose-leaf binder should be amended whenever the constitution of sections is changed.

CARBONIZATION

- C.1 Clearance of Charging Machines for Horizontal Retorts.
- C.2 Ventilation of Retort Houses, of Water Gas Plants, of Boiler Houses.
- C.3 Emergency Operation of a Water Gas Plant. Part 1—Without a relief holder. Part 2—Without a relief holder and without district gasholders. Part 3—As a steam-raising unit.

DISTRIBUTION

- D.1 Procedure for Dealing with Escapes of Gas into Post Office Plant.
- D.1a Testing for Carbon Monoxide.
- D.2 Cutting and Welding Operations on Gas Mains and Services.
- D.3 Memorandum on the Testing of Gas Mains before putting into Service.
- D.4 Recommendations to Prevent Accidents during the Cutting out of Gas Mains for Repairs and Alterations.
- D.5 Recommendations for the Maintenance of Governors used for Gas Distribution.

ELECTRICITY

- E.1 Static Electricity and Aluminium Paint.
- E.2 Notes on Electrical Safeguards in the Gas Industry.
- E.3 Safety Recommendations for Electrical Equipment in Gas Manufacture, Purification and Distribution.
- E.3a Addendum to Safety Recommendation E.3, Section 9 (Cables).
- E.4 Summary of the Position with Regard to the Use and Availability of Electrically Operated Instruments, or Instruments containing Gas Connexions and Electrical Equipment.

GASHOLDERS

- G.7 Piston-type (Waterless) Gasholder Inspection and Maintenance Records.
- G.11 Corrosion of Gasholder Sheeting.
- G.12 Anti-freezers Causing Siphoning of Sealing Water from Cups of Water-sealed Gasholders.
- G.13 Freezing of Water in Gasholders.
- G.14 Anti-freezing Device for Small Gasholders.
- G.15 Danger of Increasing Pressure of a Gasholder.
- G.16 Purging Gasholders by Means of Inert Gas.
- G.17 I.G.E. Recommendations for Gasholders. (G.17 *supersedes* G.1. to G.6 and G.8 to G.10).
- G.17a Addendum to G.17, Part III (Section I—Inspection and Maintenance.)

PURIFICATION

- P.1 Code of Practice for the Safe Operation of Oxide Purifiers.
- P.2 Draining of Purifiers.
- P.3 Scheme of Precautions against Frost on a Gas Works.
- P.4 Possibility of Explosive Atmospheres in Ammoniacal Liquor Wells on Gas Works.
- P.5 Steam Heaters for Purification Plant.
- P.7 Installation and Safe Operation of Electrostatic Detarrers.
- P.7a Addendum to Safety Recommendation P.7.
- P.7b Addendum to Safety Recommendation P.7, sub-section 4b (Purging with Clean Gas).
- P.9 Code of Practice for the Safe Operation of Tower Purifiers.
- P.9a Amendment of the Code of Practice for the Safe Operation of Tower Purifiers.
- P.10 Operation of Electro-detarrers with Carburetted Water Gas Plant.
- P.11 Recommendations for the Safe Installation, Operation and Maintenance of Exhausters, Gas Pumping Plant, Governors and Meters. (P.11 *supersedes* P.8.)
- P.12 Guarding of Tar Separators. (P.12 *supersedes* P.6.)

STILLS

- S.3 Note on Stills, Fractionating Columns, Dissociators and Preheaters. (S.3 *supersedes* S.1 and S.2.)

VALVES

- V.1 Testing of Gas Works Valves.

MISCELLANEOUS

- M.1 Asbestos Cement Roofing.
- M.2 Removal of Injurious Fumes from Stationary Internal Combustion Engines.
- M.3 Miscellaneous Emergency Experiences.
- M.4b Use of Auxiliary Charging Holes for Access to Carburetted Water Gas Plant.
- M.5 Bibliography of Literature Relating to Accident Prevention.
- M.6 (Second Amendment, March, 1961). Model Specification for Platforms, Ladders and Stairways to Provide Means of Access to Plant. (M.6 (Second Amendment, March, 1961) *supersedes* M.6.)
- M.7 Note on Coke Fires.
- M.8 Recommendations for Essential and Desirable Features that should be Incorporated in Gas Works Lifts, with Notes on Maintenance.
- M.9 (Amended March, 1961). Memorandum on Installations for the Use of Light Petroleum Distillates in Low-pressure Gasification Plants. (M.9 (Amended March, 1961) *supersedes* M.9)
- M.10 Memorandum on Precautions to be observed in the Handling of Catalysts that have been Used in the Gasification of Heavy Petroleum Fractions.
- M.11 Safe Access to Bunkers and Hoppers.
- M.12 Code of Practice for the Safe Opening of Gas Works Plant. (M.12 *supersedes* M.4 and M.4a.)

Forthcoming Meetings

The following meetings have been arranged for the six weeks commencing 1st October, 1961:

(*a*) District Sections

THE INSTITUTION OF GAS ENGINEERS—EASTERN SECTION

12th October	Visit to Texas Instruments, Limited, Bedford.

THE INSTITUTION OF GAS ENGINEERS—LONDON AND SOUTHERN SECTION

17th October	Annual General Meeting. Paper, "The Organization and Operation of a Distribution Department", by W. E. Medhurst. (2.45 p.m. The Caxton Hall, Caxton Street, London, S.W.1.)

THE INSTITUTION OF GAS ENGINEERS—MANCHESTER AND DISTRICT SECTION

10th November	Ordinary General Meeting. Paper, "Natural Gas at Whitby", by F. C. Barker. (George Hotel, Huddersfield.)

THE INSTITUTION OF GAS ENGINEERS—MIDLAND SECTION

11th October*	Autumn Meeting. Paper, "Town Gas in the Manufacture of Tubes", by A. C. Jennings and W. C. Waite. Luncheon. Afternoon visits to either the Incandescent Heat Company, Limited, or Evered and Company, Limited. (10.45 a.m. The Farcroft Hotel, Rookery Road, Handsworth, Birmingham.)

THE INSTITUTION OF GAS ENGINEERS—NORTH OF ENGLAND SECTION

5th October	Film Show on subjects of general interest to gas engineers. (The Lecture Room, Distribution Centre, Northern Gas Board, Valley Street, Darlington, County Durham.)

THE INSTITUTION OF GAS ENGINEERS—SOUTH WESTERN SECTION

18th October	Luncheon. (12.30 p.m. for 1 p.m. The Royal Hotel, Bristol.) Annual General Meeting and Chairman's Address. (2.30 p.m. South Western Gas Board, Radiant House, Bristol.)

THE INSTITUTION OF GAS ENGINEERS—WALES AND MONMOUTHSHIRE SECTION

12th October	Annual General Meeting. (The South Wales Institute of Engineers, Park Place, Cardiff.) Luncheon. (The Park Hotel, Cardiff.)

* Please note altered date.

(*b*) Junior Gas Associations

EASTERN

24th October	Visit to Vauxhall Motors, Luton.
14th November	Short Paper Competition. (Peterborough.)

LONDON AND SOUTHERN

6th October	General Meeting. Presentation of awards. Induction of new President. Presidential Address. (Westminster Technical College, Vincent Square, London, S.W.1.)
12th October	Visit to the East Greenwich Works of the South Eastern Gas Board.
3rd November	Annual Reception and Dance. (Caxton Hall, Caxton Street, London, S.W.1.)
10th November	Paper, "Maintenance of Gas Works Electrical Equipment", by W. Shaw. (6.30 p.m. Westminster Technical College, Vincent Square, London, S.W.1.)
16th November	Visit to Thomas Potterton, Limited, Warwick.

MANCHESTER

21st October	Presidential Address. Gas in Modern Industry Exhibition, City Hall, Manchester.

MIDLAND

10th October	Presidential Address.
19th October	Day Visit to W. H. Allen, Sons and Company, Limited, Bedford.

NORTHERN

21st October	Paper, "Getting Warmer", by J. Bell. (2.30 p.m. Stockton Showroom, Northern Gas Board, Thompson Street, Stockton-on-Tees.)

SCOTTISH (WESTERN)

6th October	Paper, "Work Study in The Scottish Gas Board", G. Thomson. (6.30 p.m. The Scottish Gas Board, Industrial Section, 9, George Square, Glasgow.)

WESTERN

14th October	Annual General Meeting and Presidential Address. (Bath.)

(*c*) Kindred Bodies

Members of The Institution of Gas Engineers who wish to attend any of these meetings, but are not members of the bodies concerned, should apply to the appropriate Secretary at the address indicated.

THE INSTITUTE OF FUEL

(18, Devonshire Street, Portland Place, London, W.1.)

6th October	"Under Fire"—Panel of five experts. (6 p.m. South Wales Institute of Engineers, Park Place, Cardiff.)
11th October	Paper, "Package Boilers", by A. Wilson. (6.30 p.m. The Engineers' Club, Albert Square, Manchester, 2.)
17th October	Paper, "Waste-heat Recovery", by G. H. Steward. (6.30 p.m. Gas Showrooms Lecture Theatre, Nottingham.)
25th October	"The N.I.F.E.S. Chart: a New Method of Estimating the Loss in Sensible Heat in Flue Gases, CO_2 and O_2 Basis", by T. F. Hurley and G. R. Stern. (5.30 p.m. Royal United Service Institution, Whitehall, London, S.W.1.)
2nd November	Paper, "Refractories", by H. M. Richardson. (6.30 p.m. Birmingham Exchange and Engineering Centre, Stephenson Place, Birmingham 2.)
8th November	Paper, "Coventry Water Treatment Process", by I. Aitken. (6.30 p.m. The Engineers' Club, Albert Square, Manchester, 2.)
8th November	Joint Meeting with Liverpool Engineering Society. Paper, "Gas in Industry on Merseyside", by H. C. Elles. (7 p.m. Liverpool Engineering Society's Rooms, 9, The Temple, 24, Dale Street, Liverpool, 3.)

THE INSTITUTE OF PETROLEUM

(61, New Cavendish Street, London, W.1.)

1st November	Paper, "Molybdenum Disulphide as a Lubricant Additive in Rolling Contact—A Study of Compatibility with Other Additives", by D. Scott and D. Jamieson. (5.30 p.m. 61, New Cavendish Street, London, W.1.)

THE INSTITUTION OF ENGINEERS-IN-CHARGE

(Honorary Secretary: A. T. Penn, Esq., 13, Grange Close, Edgware, Middlesex.)

11th October	Presidential Address by E. Griffiths. (6.30 p.m. Caxton Hall, Caxton Street, London, S.W.1.)
14th November	Paper, "The Contribution of Nuclear Reactors to Engineering Progress", by K. T. Wooton. (6.30 p.m. Magnet House, Kingsway, London, W.C.2.)

THE INSTITUTION OF MECHANICAL ENGINEERS

(1, Birdcage Walk, London, S.W.1.)

2nd November	Process Engineering, Refrigeration, Ventilation and Vacuum Plant Group Discussion of Problems of Maintenance in the Petroleum and Kindred Industries. (6 p.m. 1, Birdcage Walk, London, S.W.1.)

THE INSTITUTION OF PLANT ENGINEERS

(2, Grosvenor Gardens, London, S.W.1.)

4th October	"The Plant Engineer and Works Study". (7.30 p.m. Eastleigh Technical College, Chestnut Avenue, Eastleigh.)
10th October	Paper, "The Organization for Preventive Maintenance", by D. C. Muirhead. (7.30 p.m. 25, Charlotte Square, Edinburgh.)
11th October	Paper, "The Rôle of Constructional Materials in Chemical Engineering", by J. Leyland. (7 p.m. Main Engineering Lecture Theatre, The University, Bristol.)
12th October	"Accident Prevention from the Plant Engineer's Standpoint"— a tripartite meeting presented by H.M. Factory Inspector, an Industrial Officer and a member of the Scottish Branch of the Institution of Plant Engineers. (7.15 p.m. Scottish Building Centre, 425, Sauchiehall Street, Glasgow.)
12th October	Paper, "Management Problems in a Maintenance Department", by T. Gormley. (7 p.m. Roadway House, Oxford Street, Newcastle-upon-Tyne, 1.)
18th October	Paper, "The Economics of Back-pressure Generation". (7 p.m. South Eastern Gas Board Lecture Hall, 95, High Street, Rochester.)
24th October	"Clean, Correct and Careful": Film and Lecture. (7.30 p.m. South Wales Institute of Engineers, Park Place, Cardiff.)
27th October	Paper, "High-pressure Hot Water Heating", by P. Marshall and K. J. Luntley. (7.30 p.m. Imperial Hotel, Temple Street, Birmingham.)
27th October	Joint Meeting of the Manchester, Merseyside and North Wales Groups. "Why Are there Not More Engineers at Board Level?" (7.15 p.m. Aboard Clubship "Landfall", Canning Dock, Liverpool.)
1st November	Paper, "Development of Oil-cooled Rotary Portable Compressors", by P. C. Bevis. (7.30 p.m. Grand Hotel, Leicester.)
7th November	Paper, "Pilot-scale Research Work at the D.S.I.R. Warren Spring Laboratory", by S. H. Clarke, O.B.E. (7 p.m. The Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2.).
7th November	Paper, "Application of Modern Industrial Switch and Control Gear", by P. C. Belton. (7.30 p.m. White Lion Hotel, Church Street, Peterborough.)

8th November	Paper, "Organization of Planned Maintenance", by H. Bamford-Preston. (7.15 p.m. Grand Hotel, Broad Street, Bristol.)
9th November	Joint Meeting with The Institution of Heating and Ventilating Engineers. Paper, "Industrial Air Conditioning—with Particular Reference to Car Body Paint and Spray Plant", by V. C. Taylor. (7.15 p.m. The Scottish Building Centre, 425, Sauchiehall Street, Glasgow, C.2.)
9th November	Paper, "Automatic Boiler Control for Medium- and Small-size Boilers". (7 p.m. Roadway House, Oxford Street, Newcastle-upon-Tyne, 1.)
11th November	Paper, "Gas in Industry", by A. Mackechnie. (7.30 p.m. 25, Charlotte Square, Edinburgh.)
14th November	Paper, "High-pressure Hot Water Systems", by A. E. Lock. (7.15 p.m. Manchester Literary and Philosophical Society's Rooms, George Street, Manchester.)

THE INSTITUTION OF PRODUCTION ENGINEERS
(10, Chesterfield Street, London, W.1.)

17th October	The 1961 Sir Alfred Herbert Paper, "Finance for Industrial Growth", by D. L. Donne. (6.30 p.m. The Lecture Theatre, Royal Aeronautical Society, 4, Hamilton Place, London, W.1.)

THE PIPELINE INDUSTRIES GUILD
(7, Iddesleigh House, Caxton Street, London, S.W.1.)

10th October	Paper, "Routing of Pipelines in England", by A. L. Adams. (6.30 p.m. Tudor Room, Caxton Hall, Caxton Street, London, S.W.1.)
14th November	Paper, "The Thames/Lee Tunnel", by F. Tattersal. (6.30 p.m. Tudor Room, Caxton Hall, Caxton Street, London, S.W.1.)

THE SOCIETY OF INSTRUMENT TECHNOLOGY
(20, Queen Anne Street, London, W.1.)

9th October	Paper, "Instrumentation as an Aid to Fuel Efficiency", by R. Clare. (6.45 p.m. Literary and Philosophical Society, 36, George Street, Manchester, 1.)
13th October	Paper, "Differential Producers for Flow Measurement", by H. E. Dall. (6.30 p.m. Lecture Theatre, Byng Kendrick Suite, College of Advanced Technology, Gosta Green, Birmingham, 4.)
18th October	Paper, "Design of Instruments and Control Panels", by A. A. Ardley. (7 p.m. Conference Room, Roadway House, Oxford Street, Newcastle-upon-Tyne.)
19th October	The Thomson Lecture. "The Inspiration of Science", by Sir George Thomson, M.A., F.R.S. (Admittance by ticket only.)
19th October	Paper, "Computers", by J. Keay. (7 p.m. The Leapark Hotel, Bo'ness Road, Grangemouth.)
25th October	Paper, "Precision Temperature Measurement and Control", H. W. Gosling. (University College, Swansea.)
26th October	Paper, "Radiation Pyrometry", by T. Land. (7 p.m. Stanley Palace, Watergate Street, Chester.)
27th October	Paper, "The Variable Area Flowmeter Sheds its Limitations", by N. Nixon. 7.15 p.m. Scottish Building Centre, Sauchiehall Street, Glasgow.)
1st November	Paper, "Modern Instrumentation Applied to Gas Distribution", by H. S. Horn. (7 p.m. The University, Department of Fuel Technology, Mappin Street, Sheffield.)
9th November	Paper, "Our Technology and Our Society", by G. C. Eltenton. (7 p.m. Merseyside and North Wales Electricity Board Industrial Centre, Paradise Street, Liverpool.)
9th November	Symposium of Modern Instrument Maintenance. "Job Methods and Scheduled Maintenance", by J. R. Gordon. "Organizing the Work of a Maintenance Section", by J. Dunkley. "Keeping Maintenance Costs to a Minimum", by D. M. Bishop. "Test Equipment for Maintenance Purposes", by G. White. (7.30 p.m. Cleveland Scientific and Technical Institution, Middlesbrough.)
10th November	"The Mathematics of Process Control", by P. G. Farley. (6.30 p.m. College of Advanced Technology, Gosta Green, Birmingham, 4.)
13th November	Joint Meeting with The Institute of Physics and The Physical Society. "The Rôle of the Physicist in Plant Instrumentation", by L. J. R. Postle, Ph.D. (The University, Manchester.)

In this Issue...

H. Weittenhiller

H. Weittenhiller was born in 1897 in Wetter (Ruhr, Westphalia). After finishing his studies in chemistry, he turned to the chemistry of coal and was first a coke oven engineer and later coke oven manager and a director of a large steel undertaking. In this capacity, he was closely connected with the development of the Fischer-Tropsch synthesis and was the first to carry out this synthesis on a technical scale under pressure with the object of producing, primarily, solid paraffins that were used also, to some extent, as raw materials for edible fats. When the Fischer-Tropsch synthesis ceased to be economic, owing to greatly increased coal prices, Dr. Weittenhiller was for seven years a director of a leading German company producing refractory materials, and in this connexion he constructed coke ovens, gas works and by-products plants. In 1954, he became Chairman of Steinkohlengas, A.G., and introduced the practical gasification of caking coals with oxygen under pressure.

F. J. Eaton, Ph.D., studied chemistry at the University of Edinburgh and the Heriot-Watt College, obtaining the B.Sc. degree in 1921 and Ph.D. two years later, when he joined the research department of the Gas Light and Coke Company under Dr. H. Hollings. After working on gas drying, and making a reactive coke from briquettes, he became Works Chemist at Richmond in 1929 and assisted with the full-scale test on low-temperature carbonization and production of "Gloco". His interest in coke dates from his return to the Fulham Laboratory in 1931. He became Coke Development Officer in 1948 and Deputy Manager, Watson House, in 1954. His knowledge of gas utilization he attributes to daily tuition from Mr. L. W. Andrew and his colleagues at Watson House, and to having partnered Mr. F. C. Smith for 15 years of lecturing at the Westminster Technical Institute. Dr. Eaton has served on various Committees of, and collaborated in a number of Papers to, the Institution.

Guy Hamilton Fuidge, B.Sc., was born on 10th March, 1901, and educated at Taunton's School, Southampton, and at the Sir John Cass College of the University of London, where he graduated in chemistry, physics and mathematics. He entered the Chemical Laboratory of the South Metropolitan Gas Company in 1919, as a chemist and research assistant dealing with problems of gas production and purification. In 1928, he became Senior Research Chemist. He was appointed Chief Physicist to the Company in 1948, which appointment was confirmed by the South Eastern Gas Board upon nationalization of the gas industry. Mr. Fuidge became Manager of the Central Laboratories of the Board in 1958. He is the author of numerous papers on coke, tar, and the combustion characteristics of town gas, and has collaborated in reports on corrosion problems in gas appliances. Mr. Fuidge has given valuable service on a number of important committees dealing with gas utilization, solid fuels, tar and other bituminous products, and the technical and utilization aspects of coke development, as well as to a number of panels of the British Standards Institution. He was awarded the Institution's Gold Medal for 1955, as joint author of a paper, "The Tolerance of Aerated-burner Appliances to Variations in the Combustion Characteristics of Town Gas", presented to the 21st Autumn Research Meeting of the Institution on 22nd November, 1955.

D. R. Wills, B.Sc.,(Hons.Eng.), A.C.G.I., received his engineering training with the L.M.S. Railway during the period 1919 to 1930. He graduated at the City and Guilds Engineering College, and, after a further short period on production development in railway engineering, was appointed to the staff of the City and Guilds Engineering College and was engaged in lecturing and research, including heat transfer, heating and fuel problems. He joined the Gas Light and Coke Company in 1935 as a technical adviser to the equivalent of the present Headquarters Division of the North Thames Gas Board. During the early part of the Second World War he was seconded to the Distribution Engineers' staff at Headquarters Central on civil defence work, was commissioned in the Royal Electrical and Mechanical Engineers, and served in Britain and India. He rejoined the North Thames Gas Board at Watson House in 1947 and is now head of the Space Heating and Aerodynamic Laboratories. Mr. Wills has served on various Committees of, and collaborated in a number of papers presented to, the Institution.

A photograph including Dr. Eaton, Mr. Fuidge and Mr. Wills appears on p. 671.

Centenary Celebrations of the Scottish Association of Gas Managers

The Centenary Meeting of the Scottish Association of Gas Managers was held in the Music Room, George Street, Edinburgh, on Thursday, 14th September, 1961, under the Presidency of Mr. David Beavis.

The delegates were welcomed to the City of Edinburgh by Bailie Robert McLaughlin, who deputized for the Lord Provost.

This Centenary Meeting was to be the last meeting of the Scottish Association of Gas Managers. The development and organization of the gas industry during the last decade has rendered the constitution of the Scottish Association inappropriate for current conditions, and it was agreed that the Association, on the completion of its Centenary, should become the Scottish Section of The Institution of Gas Engineers.

A number of eminent guests attended the meeting, including the Chairman of The Gas Council, Sir Henry Jones, M.B.E.; the Chairman of The Scottish Gas Board, Mr. Sydney Smith, C.B.E.; the President of The Institution of Gas Engineers, Mr. T. C. Battersby, M.B.E.; the Under Secretary (Gas Division), Ministry of Power, Mr. J. A. Beckett, C.M.G., and the Secretary of The Institution of Gas Engineers, Mr. A. G. Higgins, all of whom paid tribute to the work of the Scottish Association of Gas Managers during the last 100 years and wished it well in its new rôle as a Section of the Institution. Sir Henry Jones gave a brief account of the present position of the gas industry in general, and Mr. Sydney Smith referred to the gas industry in Scotland.

In addition to the above-mentioned guests, there were present the Senior Vice-President of the Institution, Dr.

A. E. Haffner, and a number of its Past Presidents : Dr. J. Burns, G.M., Deputy Chairman, North Thames Gas Board; Mr. J. H. Dyde, O.B.E., Chairman, Eastern Gas Board ; Mr. E. M. Edwards, Deputy Chairman, Wales Gas Board ; Mr. D. D. Melvin, Member, The Scottish Gas Board, and Mr. W. K. Tate, Managing Director, Main Morley, Limited, Padiham.

The Presidential Address was delivered by Mr. Beavis, and the William Young Memorial Lecture, entitled "William Young in Practice and in Theory", was given by Dr. J. Burns, G.M.

In the afternoon, a film entitled "The Murton Coking Plant", produced by the National Coal Board and the Woodall-Duckham Construction Company, Limited, was introduced by Mr. C. Kuttner, of the Woodall-Duckham Construction Company, Limited, and Mr. H. Millner, Carbonization Engineer, Durham Division, National Coal Board, replied to questions raised thereon.

A paper entitled "An Eye to the Future", by Mr. M. R. Bone, of the South Eastern Gas Board, was presented and discussed.

At the conclusion of the meeting, Mr. Beavis invested Mr. D. L. Dickson, of Dumfries, as Chairman of the Scottish Section of The Institution of Gas Engineers.

It is hoped to give a fuller account of this meeting in a forthcoming issue of the *Journal*.

Library Accessions

The following are a few additions to the Library since the issue of the *Journal*, Vol. 1, No. 9, September, 1961:

Applied Chemistry for Engineers (3rd Edition), by E. S. Gyngell. (Arnold, 1960.)

A.P.V. Pulsed Column, by O. W. Molony and G. Davies. *Benzole Producers Limited Research Paper* 3-1961.

* Benzoles. Production and Uses, edited by G. Claxton. (National Benzole and Allied Products Association, 1961.)

Boletín Estadístico Anual Ejercicio, 1959-60. (Gas del Estado, Buenos Aires, 1961.)

British Standard 526:1961 (Definitions of the Calorific Value of Fuels).

British Standard 1747:Part 1:1961 (Methods for the Measurement of Air Pollution: Part 1: Specification for Deposit Gauges).

British Standard 2973:1961 (Classification and Methods of Sampling and Testing of Insulating Refractory Bricks).

British Standard 3369:1961 (Specification for Unified Miniature Screw Threads).

British Standard 3377:1961 (Specification for Back Boilers for Use with Domestic Solid-fuel Appliances).

British Standard 3378:1961 (Specification for Domestic Heating Stoves Using Coke and Other Solid Fuels).

British Standards Institution Annual Report, 1960-61.

Datos Estadísticos Tecnicos de la Industria del Gas. Produccion, Distribucion y Consumo, 1960. (Servicio Sindical de Estadistica, Sindicato Nacional de Agua, Gas y Electricidad, Madrid.)

Elsevier's Dictionary of the Gas Industry. In Seven Languages. (International Gas Union, 1961.)

Etude des Dispositifs de Protection Destinés aux Appareils d'Utilisation du Gaz. (Association Technique de l'Industrie du Gaz en France.)

Factories Act, 1961. Ch. 34.

Gaz—Energie Nationale. (Société pour le Développement de l'Industrie du Gaz en France.)

Guide to Current Practice, 1959. 2nd edition, revised. (The Institution of Heating and Ventilating Engineers.)

History of Flow Measurement by Pressure-difference Devices. (George Kent, Limited.)

Inspectorat Technique des Usines à Gaz Suisses. Quarante-huitieme Rapport Annuel, 1960. (Société Suisse de l'Industrie du Gaz et des Eaux, 1961.)

VII International Ceramic Congress, London, May, 1960. A Souvenir Published by the British Ceramic Society.

Proceedings of the International Symposium on Distillation, Brighton, May, 1960. (The Institution of Chemical Engineers.)

Reports on the Progress of Applied Chemistry, Vol. 45, 1960. (Society of Chemical Industry.)

Using Foaming Agents to Remove Liquids from Gas Wells, by H. N. Dunning, J. L. Eakin and C. J. Walker. (*U.S. Bureau of Mines Monograph* 11, 1961.)

Welding Handbook, 4th edition, edited by A. L. Phillips. Section 4: Metals and Their Weldability. (American Welding Society, 1961).

Journals Recently Added to the Library

British Journal of Non-destructive Testing.

British Power Engineering. No. 1.

Coke and Chemistry, U.S.S.R.

Domestic Heating News.

Industrial and Process Heating.

Pipes and Pipelines.

* Purchased out of the Glasgow Bequest.

General Notices

International Factory Equipment Exhibition

The International Factory Equipment Exhibition and Conference will be held at Earls Court, London, from 13th to 18th November, 1961.

The exhibition has the full support of The British Productivity Council, which will be responsible for several conferences including those on "Organizing for product quality", "Ergonomics in the factory: fitting the job to the worker", "Industrial change and human effects", "Low cost automation" and "The effective use of capital".

A complimentary ticket for the exhibition will be included in the November issue of the *Journal*.

Conference on Engineering Materials and Design

A Conference on Engineering Materials and Design will be run concurrently with the Second Engineering Materials and Design Exhibition to be held at Earls Court, London, on 13th to 17th November, 1961. Subjects to be discussed are covered by the broad headings of: materials, components, and factors of design. Prior to the conference, holders of season tickets (£3 3*s*., non-transferable) will receive a bound volume of all papers to be read; holders of daily tickets (£1 1*s*., non-transferable) will receive copies of the papers to be read on the day for which they are registered.

Further particulars and registration forms may be obtained from the Secretary, Second Engineering Materials and Design Conference, Commonwealth House, 1-19, New Oxford Street, London, W.C.1.

Maintenance Conference and Exhibition

A National Maintenance Conference and Exhibition has been arranged for 13th to 16th November, 1961. The first of its kind ever to be held in Britain, it will take place in the Central Hall, Westminster, S.W.1. One of the objects of the conference, for which a fee of £2 2*s*. a day, or £5 5*s*. for the full conference, is payable, will be to encourage scheduled maintenance, which is increasingly essential if industry is to benefit from automation.

The four-day conference will ensure adequate coverage of the maintenance manager's work, and discussion groups will give an opportunity for the exchange of views on problems in various industries. The chairmen and speakers have been selected by a Conference Committee composed of practising engineers. The exhibition will be mounted by companies prominent in the field of plant maintenance, and their latest products and processes are expected to be displayed.

Further information and delegates' registration forms may be obtained from the Conference Organizer, National Maintenance Conference, 1961, Mercury House, 109-119 Waterloo Road, London, S.E.1.

Institution Necktie

The Council of the Institution, in response to a number of requests from members, has arranged for the manufacture of an Institution tie, which will enable members readily to identify other members they meet and with whom they associate both in work and socially.

The design incorporates a motif taken from the Institution's coat of arms and consists of a crown and two crossed torches. The tie is made of silk with the motif on a blue background. (See photograph, p. A28.)

In order that the sale of the ties shall be restricted to members of the Institution they will be obtainable only from the headquarters of the Institution or from district sections at 17*s*. 6*d*. each, post free. This price will enable a contribution of 5*s*. for every tie sold to be made to the Benevolent Fund of the Institution.

Orders may be accompanied by the appropriate remittance and should be addressed to the Secretary, The Institution of Gas Engineers, 17, Grosvenor Crescent, London, S.W.1.

Library

The Library and Reading Room of the Institution are open on weekdays between 9 a.m. and 5.30 p.m. Members may borrow books by post, excepting books of reference and certain others, on application to the Secretary.

Benevolent Fund

Contributions to the Benevolent Fund of the Institution may be paid at any time to the Secretary of the Benevolent Fund, 17, Grosvenor Crescent, London, S.W.1. It is a convenience if annual contributions are made by banker's order, and it is particularly advantageous to the Fund if such contributions are made by Deed of Covenant whereby the Fund is able to reclaim from the Inland Revenue an appropriate sum in respect of income tax paid by the contributor. Further particulars, with deed forms and banker's orders for completion, are obtainable from the Secretary of the Fund.